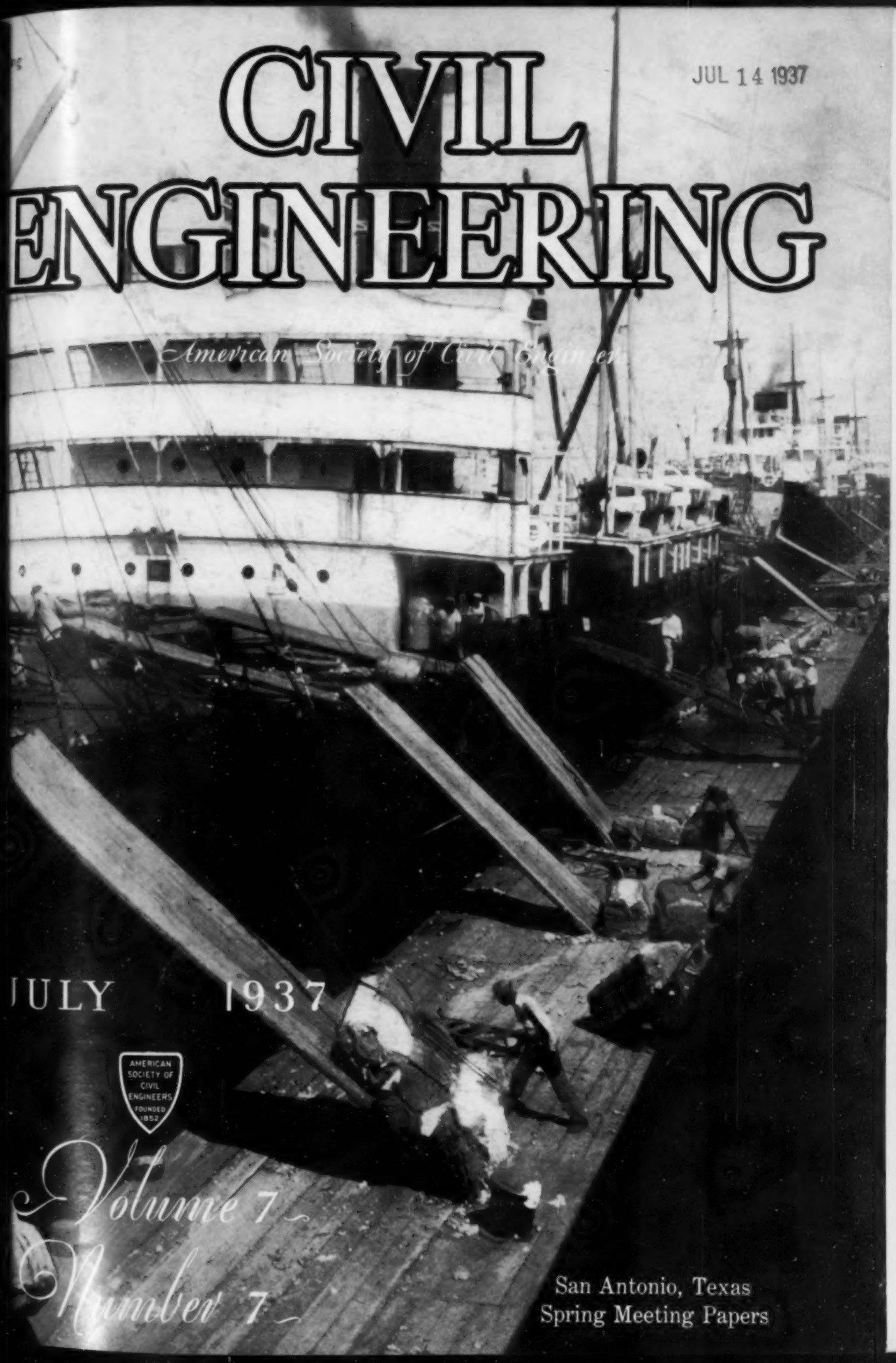
JUL 14 1937

CIVIL ENGINEERING

American Society of Civil Engineers



JULY 1937

AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852

Volume 7
Number 7

San Antonio, Texas
Spring Meeting Papers

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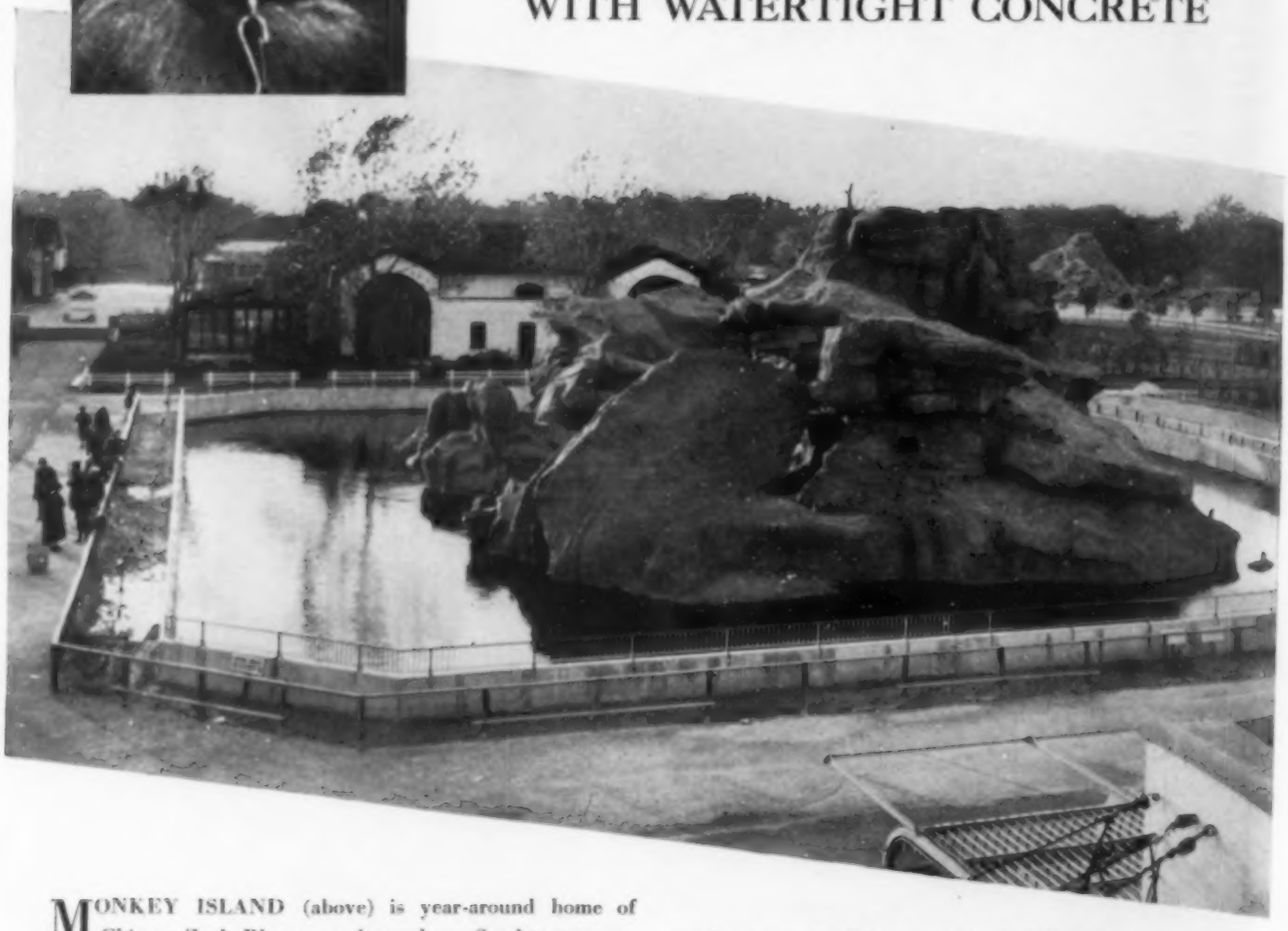

MONKEY ISLAND (above) is year-around home of Chicago Zoo's Rhesus monkey colony. Sandstone crags, beaches and trees make a picturesque outdoor setting. Retiring houses, concealed in the rock-work, electrically heated and ventilated, provide cozy winter quarters.

The Rhesus monkey, hailing from North India and South China, is a great swimmer and diver. Hence, the water-filled moat which surrounds the island. The moat's concrete walls are 18 feet high, water is 14 feet at greatest depth. Outside moat dimensions, 180′ x 130′.

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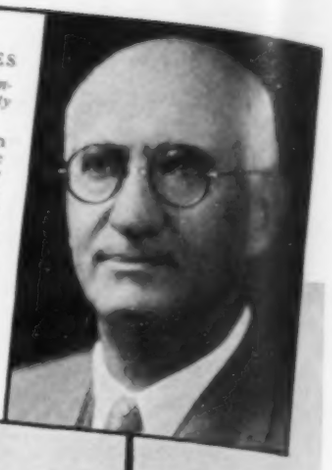

EDWARD N. HINES
Board of County Road Commissioners, Wayne County (Detroit), Michigan

"To Edward N. Hines, in recognition of his notable contribution to highway safety through the introduction of the center traffic line now in universal use" —reads the plaque presented by the B. F. Goodrich Company in 1936. The plaque was presented to Mr. Hines only after the Goodrich Company had searched the entire country to determine the originator of the center traffic line idea.

Traffic markers and curbing of Atlas White Portland Cement in Michigan Superhighway, near Dearborn. Installed by Board of County Road Commissioners, Wayne County. J. K. Norton, Road Engineer.

EVEN as far back as 1912, traffic had its problems. It was in that year that Edward N. Hines of the Wayne County Road Commissioners, (Detroit), Michigan—aiming at the "road hog"—hit on the idea of running a white stripe down the center of roads and streets.

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M-12

ATLAS WHITE PORTLAND CEMENT
FOR TRAFFIC MARKERS

Something to Think About

A Series of Reflective Comments Sponsored by the Committee on Publications

Arbitration versus Litigation

By MALCOLM PIRNIE
MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS
CONSULTING ENGINEER, NEW YORK, N.Y.

SOME years ago, when a great bridge was to be built across an interstate waterway, a rare instance of foresight was recorded. To prevent possible controversies from creating litigation, an arbitration clause was provided in the contract. Whether or not the fact that no disputes arose requiring arbitration was a result of the presence of this clause, this much is certain—in the event a dispute had occurred, it could not have clouded the progress of the work.

It is a pity such instances cannot be multiplied indefinitely. Granted, that arbitration is widely used in the construction field; yet engineers have lagged behind others in recognizing its value. As a result, the majority of contracts still make no provision for appeal from the engineer's decision on all matters of dispute. Small wonder then that such projects are so frequently menaced with the danger of litigation.

To Cover Contingencies.—Not only did the engineers who drew up this bridge contract visualize clearly the future value of a provision for arbitration; they also realized that such a provision must be accurately drawn or it would fall short of being as effective as the other specifications. The following clauses were therefore drafted:

". . . . The engineer shall in the first instance be the interpreter of the contract.

"All decisions of the engineer shall be final except as to the element of time and as to financial considerations involved, which, if no agreement in regard thereto is reached, shall be subject to arbitration under the published Arbitration Rules of the American Arbitration Association, and pursuant to (State) Arbitration Law . . . .

"All questions subject to arbitration under this contract shall be submitted to arbitration at the demand of either party to the contract.

"Demand for proposed arbitration shall be filed in writing with the engineer, in the case of an appeal from his decision within ten days of its receipt; in the case of any other dispute such demand shall be so filed with the engineer within a reasonable time after the dispute has arisen; but in no case shall such demand be filed later than the time of final payment . . . . If the engineer fails to make a decision within a reasonable time, an appeal to arbitration may be taken as if his decision has been rendered against the party appealing.

". . . Arbitration shall be demanded by the service upon the opposing party of written notice to proceed therewith within three days after service of such notice."

Doubtless other regulations could have been equally effective. Note, however, that certain most valuable details were carefully included. First, there was specific provision as to procedure when a dispute arose, so that the parties could make it immediately effective the moment they desired; definite rules were indicated, ensuring that the arbitration would be conducted in conformity with the prevailing arbitration statutes; and the American Arbitration Association was named to administer the arbitration. This made available facilities that would be ready for use at a moment's notice; the hearings could be arranged by the trained staff of the Association, and the arbitrators could be chosen from its national panel. Finally, since the engineer was to be given the original jurisdiction, arbitration would not have to be resorted to unless the dispute were so serious as to nullify the usual provisions of settlement.

Often arbitration is resorted to after a controversy has arisen. In such cases, the parties sign a Submission Agreement. But however it may be determined upon, arbitration procedure is simple and direct. A trade association or even some purely local group may be utilized, or the case may be referred to the American Arbitration Association, to take advantage of its national facilities. This Association maintains a panel of arbitrators selected from all professions in each of 1,600 cities throughout the country. It is an altruistic organization, drawing support from all professions, that has had the friendly cooperation of the Society for many years.

A Simple Procedure.—When parties to a dispute agree to use its facilities and have furnished a short statement covering the nature of the dispute, the Association sends to all of them identical lists of members of its panel of arbitrators, comprising those expert in the field of the controversy in that locality. Each party then eliminates

names that are not satisfactory and returns the list. From the remaining names common to each list three arbitrators are appointed. At the hearing each party presents his case with or without the aid of counsel, as agreed in advance. The award, handed down within thirty days after the close of the hearing, will be enforced as a judgment of the court having jurisdiction.

This is a direct and sensible procedure, yielding within a few days a settlement that might well have taken years in court. It is a final determination of the controversy—it cannot be appealed. As men with experience hear the case, there is no need to hire experts to interpret the testimony presented. As the arbitrators serve without compensation, the cost is only that of the nominal fee, which goes to the Association to cover its expense. As the hearing is private, there is no publicity.

Arbitration is no haphazard procedure; it is regulated by both federal and state laws. A court may review a case to see that it has been conducted according to arbitration law—that is, to see that there has been voluntary agreement by both parties to arbitrate, and that the hearing has been by impartial persons who have given the case a fair trial. But other than this the courts do not interfere; once the parties have agreed on arbitration, the arbitrators' decision is final as to the facts of the case, and will be confirmed and enforced if the arbitration has been properly conducted.

Looking at the Record.—Arbitration has an enviable record of achievement. It has proved its value to those who have used it. Since 1915 a number of the Standard Documents of the American Institute of Architects have recognized arbitration, by providing for appeal from the Architect's decision. Of course, there was no magic wand to make arbitration immediately useful in all circumstances. For years the Documents provided for choosing arbitrators "within a reasonable time if the Architect failed to render a decision." What was a "reasonable time"? So long as this remained to be determined by belligerent parties it added a question in dispute, instead of offering settlement of the primary controversy. The arbitrators when appointed were faced with the problem of proper and effective procedure often without precedents in their experience. Awards were often overthrown by the courts because hearings were not conducted according to arbitration law.

A new plan was drafted in 1932 and has recently been adopted. The result of many years of trial and error, it provides constructive suggestions for adapting arbitration to engineering contracts. Because the inclusion of lengthy Rules of Procedure in the contract form was impracticable, an Arbitration Plan was adopted as a separate document to be referred to and made a part of the contract. Under such definite rules arbitration can proceed in an orderly manner at the request of either party, and in accordance with arbitration law, to preclude the possibility of litigation. An option is provided whereby upon the request of either party, the arbitration will be administered by the Association. Similarly, the Association is also named to appoint a third arbitrator in cases where agreement cannot otherwise be reached.

Reluctance Hardly Justified.—Why, it may be asked, have engineers as a group failed to develop a similar standard of arbitration? In the first place, the practice of naming the engineer to settle all disputes under a contract has been pretty generally accepted as a sufficient gesture in the direction of providing for arbitration. But though this is a practical and usually a successful means of avoiding litigation, the engineer is, despite his best intentions and high integrity, an interested party to the dispute, and he can never be an arbitrator in the true sense of the word. While his position should remain as it is, the highest authority for a particular job, there is a real need for providing a neutral agency other than the courts to which appeal can be taken from his decision on questions of payment.

Another reason why engineers have failed to provide a standard of arbitration may be found in their ingrained conservatism—in this instance, perhaps, occasioned by lack of familiarity with, rather than by fundamental objection to, the arbitration idea. Accustomed to look on both sides of any question, the engineer sees in this question certain advantages and objections that he may not be prepared to weigh accurately. While the architect frequently represents a single owner, thus simplifying his relationship, the engineer more often deals with a group of owners, such as a town council, board of aldermen, or perhaps a commission. Furthermore such public representatives feel their responsibility to the public and are very sensitive to criticism, whether or not it is just.

When first such an innovation as arbitration is proposed, someone immediately asks, "Why not follow the old routine? That, with all its drawbacks, is at least an acknowledged method." And if, by chance, the arbitration does not eventually support the commission's point of view, critics may question its judgment in selecting this method; may even charge that it has not exhausted every possibility, such as following a case through succeeding courts of law. Though such a charge is hardly tenable, yet the commission and its engineers may find in it a cause of natural reluctance.

History Teaches Confidence.—To this as to every other reaction against progress, the answer is in experience and education. Certainly the record of arbitration is the strongest argument for its adoption. That record, constantly in the making, should be broadcast to every engineer, so that each of us can satisfy himself that arbitration is intrinsically valuable. Then, as a profession, we can decide for ourselves just how it shall be put in practice. Whether we adopt our own rules and maintain our own facilities, or use the established facilities of the American Arbitration Association, or work out a plan combining both methods, we must have definite rules and standards for the entire profession if arbitration is to be most effectively employed.

There is a pithy little rhyme about the auto driver who died defending his claim to the right-of-way. Most legal collisions on engineering jobs result from precisely the same bullheadedness; each party is morally certain that justice is his, and his only. Usually both parties get hurt. But with arbitration there is no assumption of superior justice; contacts tend to be friendly rather than bitter; the legal expenses are moderate, not grave.

It is with a deep realization of its proven advantages that I have offered these comments on arbitration, not as a medicine man who has discovered the infallible cure but as a challenge to further meditation.

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VOLUME 7 NUMBER 7

Industrial Development of Texas

Physical Conditions Encourage Progress in Transportation and Many Diversified Industries

OF immense size, with climate ranging from subtropical to cold, Texas constitutes an ideal field for the development of transportation facilities and of numerous other and larger industries. The Texas Planning Board, created in 1935, has made detailed studies of the state's industries and resources. The accompanying articles, abstracted from papers delivered on April 21, 1937, at the San Antonio Meeting of the Society, include an introductory one describing the Board's activities and two on the industries which have been the subjects of its study. Articles dealing with Texas resources appear elsewhere in this issue.

The program of the Texas State Planning Board, as outlined by Mr. Youngblood in the opening article, aims at the conservation or the development of public health; land use; water resources; forestry; mineral resources; industrial resources; education; governmental and social improvements; and mapping. In the second article, Mr. Smith traces the development of the Texas railroads from the single 2-mile line completed in 1856 to 102 roads operating nearly 23,000 miles of track in 1934. In the final article, Mr. Tuttle includes material on 36 different Texas industries, both existing and potential.

Program of the Texas Planning Board

By HULL YOUNGBLOOD
VICE-CHAIRMAN OF THE TEXAS PLANNING BOARD, SAN ANTONIO, TEX.

PLANNING is looking forward; nothing more and nothing less. Planning is not new—it is frequently mentioned in the Bible—and few of our activities do not require some sort of planning. It is this ability to plan for the present and for the future that distinguishes the human race.

It is also natural and logical for a community, county, state, or nation to plan for today and for tomorrow. But such planning must be done collectively, and this is where the professional planner finds his niche. The welfare of each and every individual must be taken into consideration before a community plan can be drawn up. Today we are concerned with the coordinated planning of a great land area such as Texas. Here we are confronted with problems on such a scale as are faced by no other state planning agency.

The terrain of Texas slopes from the north and northwest down to the Gulf like a slightly inclined amphitheater, and the state is divided physiographically into four great regions. First, there is the coastal plain lying between tidewater and the Balcones escarpment and its northern extension to the blackland belt of the Red River, which separates Texas and Oklahoma. Then there is the rolling upland region of the central and north central parts of the state, extending from the Colorado to the Red River, and lying between the black lands on the east and the foot of the high plains on the west. Next are the Great Plains, lying west of the uplands. Finally, on the far western horizon rise the mountain peaks of the Guadalupe, Davis, Chisos, and other trans-Pecos ranges. This diversity of physiography, with attending variations of soil, temperature, rainfall, and indigenous vegetation, makes Texas the state of contrasts.

STREET SCENE IN SAN ANTONIO

IMMENSE SIZE OF THE STATE

Texas extends through more than 10 deg of latitude, and has a maximum dimension of 801 miles from the southern tip, near Brownsville to the northwestern corner of the Panhandle. The greatest distance from east to west is 773 miles. The land area of the state is 262,393 sq miles, and the water surface 3,498 sq miles.

The maximum annual temperature (at Rio Grande in Starr County) is approximately 74 F; the minimum (at Dalhart in the upper Panhandle) is approxi-

mately 54 F—a spread of 20 deg. In the Rio Grande Valley there is seldom frost. At Vega, in the Panhandle, there is an average of 24 in. of snow. Again, on the eastern border the annual rainfall is more than 50 in., whereas at El Paso on the west the average is less than 10 in. Between these extremes of temperature and rainfall are many gradations.

WEST CORINTH STREET VIADUCT, DALLAS, TEX.

Texas has a pine-timber belt as large as the state of Indiana, and an area along the coast, lying less than 150 ft above sea level and having a subtropical climate, equal to the area of South Carolina. It has an area as large as Pennsylvania lying in the middle temperate climate, 75 per cent or more cultivable, and varying in altitude from 3,000 to 4,000 ft above sea level. Texas has a mountainous area west of the Pecos as large as the state of West Virginia; an area of good farming country in the central and mid-western part equal to the area of Ohio and Kentucky; and an area on the Edwards Plateau, admirably adapted to cattle, sheep, and goat raising and diversified crop production, as large as the state of Tennessee. With the third longest coastline among the states, Texas is nevertheless a great inland empire.

These comparisons show only a few of the things the Texas Planning Board must take into consideration. What is good for East Texas is not good for West Texas, and the same can be said for South and North Texas. Before a comprehensive program can be carried out for the state, floods must be controlled. The maximum discharges per square mile of area experienced in Texas with few exceptions exceed rates from areas of comparable size anywhere in the United States.

For instance, the greatest flood on record on the Trinity River at Dallas, draining an area of 6,000 sq miles, occurred in May 1908, with an estimated discharge of about 250,000 cu ft per sec. The Connecticut River, comparable in size with the Trinity, went on its greatest rampage in March 1936. At Vernon, Vt., where the drainage area is 6,220 sq miles, the discharge of flood water was 185,000 cu ft per sec, or 29.8 cu ft per sec per mile.

Last September, the mighty Brazos River broke all flood records at Waco, where the effective drainage area is approximately 19,300 sq miles, with a peak discharge of 240,000 cu ft per sec. On September 10, 1921, the Little River at Cameron, draining an area of 7,034 sq miles, discharged 647,000 cu ft per sec. The Guadalupe River at Victoria drains an area of 5,676 sq miles. The flood crests at this point are generally reduced by temporary storage in wide overflow areas adjacent to the main channel, yet a discharge of about 180,000 cu ft per sec was measured at Victoria on June 3, 1936.

The Rio Grande, however, furnishes us with the most impressive comparison. The greatest flood of record on this river occurred in September 1932. The peak discharge at Del Rio was 605,000 cu ft per sec, coming principally from Devils River, which drains an area of about 4,000 sq miles and enters the Rio Grande about 12 miles above Del Rio. The peak discharge of Devils River was 597,000 cu ft per sec. On the other hand, the maximum discharge at Grand Coulee Dam on the Columbia River (draining an area of 74,100 sq miles) was only 492,000 cu ft per sec in the period of record 1913–1936. The average annual loss from floods in Texas is about $25,000,000, and the proper harnessing of these streams at flood stage must be considered in any kind of a long-range planning program.

PLANNING BOARD CREATED IN 1935

When the Texas Planning Board was created by the Forty-Fourth Legislature in March 1935, it divided its program into nine phases. Each phase was entrusted to a committee of experts for study and recommendations, under the guidance of a member of the board. The program includes public health, land use, water resources, forestry, mineral resources, transportation, industrial resources, educational projects, governmental and social aspects, and mapping.

According to the data compiled by the public health committee, deaths in Texas in 1934 from preventable, infectious, and parasitic diseases totaled 10,116, and an additional 7,451 persons succumbed to the ravages of pellagra, pneumonia, diarrhea, and enteritis. Deaths from preventable diseases for that year thus represent one-third of the state's entire mortality. It is probable that the unusual death rate from some of these diseases is due in part to climatic conditions and to living conditions in certain areas. But this situation merely demonstrates the extent of the improvements which are needed.

If the value of a human life is taken as $10,000, then Texas suffered an economic loss of $172,670,000 in 1934 from preventable diseases alone. Estimating the average cost of each funeral at $200, the 17,576 preventable deaths in 1934 represent an actual expenditure of $3,513,400 by the relatives of the deceased. It is therefore logical to consider conservation of public health along with conservation of natural resources.

Studies indicate that almost any agricultural product can be produced within the state, although Texans in general are dependent upon one, two, or three crops at most. The Planning Board believes that diversified farming should be practiced to conserve the fertility of the soil, lessen the vicissitudes arising from variations in price and market demand, produce a higher standard of living, and provide more opportunities for increasing farm income. A land policy is accordingly being prepared along these lines.

Texas has been blessed with an abundant supply of mineral resources, including gold, silver, lead, zinc, copper, iron, and many kinds of building stone and nonmetallic minerals. The collection of data on the location, size, and commercial quality of the mineral deposits constitutes an important phase of the planning program.

CONSERVATION OF TIMBER IMPORTANT

The great forests which blanket East Texas not only support a large and thriving lumber industry but also promise to furnish plenty of Texas-made newsprint. As some of these East Texas forests have been cut over with no thought of the future, the board must formulate some kind of a plan to place them on a sustained-yield basis. Also included in this general project is the plan to create auxiliary state forests, wherein taxes will be paid only on bare land, with severance taxes additional wherever timber is cut. Through this plan it is believed that a large amount of submarginal land will be retired to timberland, for which it is admirably suited, and new forest areas created.

Other resources are transportation facilities, both existing and to be developed. Texas has a coastline of 624 miles, which must be developed along with the expansion of inland transportation facilities. When this coordination is accomplished, raw materials and products can be shipped with ease to the ports of the world.

It is logical that industry should follow agriculture, but it is not always easy to attract industry within the far-flung borders of the state. The manufacturer prefers to be near his major markets; he likes a bountiful supply of suitable labor; he wants adequate and cheap transportation facilities to bring his raw materials to the waiting machinery and to take the finished product to the consumer; he considers materials, fuel, power, and closeness to related industries; and finally, he is interested in the conditions under which his employees must live. Until the planner provides a market, there is little likelihood that manufacturers will be drawn to Texas even by the cleverest ballyhoo. Facts must first be gathered and welded into a convincing array of data.

Another problem is that of eliminating illiteracy, providing additional facilities for adult education, and furnishing increased library facilities for the great masses of people in the rural regions. Government and social aspects also fill an important place in the planning scheme. Provision must be made for the indigent, the needy blind, and those who are physically unable to make their own living. Economy may perhaps be effected through the centralization of government and the consolidation of counties. By no means least important are topographic maps of the state. There are some sections where a stake has never been driven into the ground or a line run. Nothing can be done for these sections until adequate maps are available.

Here then is the nine-point, long-range planning program which the Texas Planning Board is working upon. Only after these various phases of study have been completed and recommendations drawn up will a comprehensive plan for Texas become a reality.

A TYPICAL TEXAS RANCH SCENE IN NOLAN COUNTY
These Vast Ranches Are Now Being Cut Up Into Small Farms

The Railroads of Texas

By GEORGE C. SMITH
ASSISTANT TO PRESIDENT, MISSOURI-KANSAS-TEXAS LINES, ST. LOUIS, MO.

TRANSPORTATION is an essential part of every industrial activity, and the annihilation of distance has always been, and will always be, a problem in the development of Texas resources. In 1934 there were 21 Class I, 15 Class II, 29 Class III, and 37 lesser railroads in Texas, operating 16,660 miles of first main-line track, 208 miles of second main-line track, 1,028 miles of industrial, and 5,000 miles of yard track—a total of 22,936 miles. The larger roads are shown in Fig. 1.

Texas is often spoken of as a state of magnificent distances. Its size has made transportation a more important factor than in most other parts of the United States. No other state has greater need for transportation, and none has pursued more liberal and determined policies to provide a sufficiency of it. A brief historical review will show this to be so.

Until railroads were built, Texas had a limited and much circumscribed development which, agriculturally, was confined to cotton in a few counties along the Gulf coast. Cotton was the only crop sufficiently valuable and non-perishable to justify water transportation, with its long delays, and which would still be worth the ocean freights charged to take it to consuming markets. A small part of the lumber of East Texas, because of navigable rivers available for at least a part of each season, was also capable of being marketed. The rest of the state, almost all of it, was obliged to raise self-transporting crops, mainly cattle.

The economic history of Texas and of its railroads falls naturally into four eras, which may be called the pioneer period (1836–1876), the settlement period (1876–1900), the period of city development (1900–1925), and the competitive period (1925–1937). The first historical period referred to extends from the time of the independence of Texas (1836) to the adoption of a new state constitution, February 15, 1876. The other periods lie wholly under that constitution and its amendments and are distinguishable because of economic rather than political events.

During the days of the Republic no railroads were

THIS IS NOT A SPANISH MISSION, BUT THE SAN ANTONIO PASSENGER STATION OF THE MISSOURI-KANSAS-TEXAS LINES

built within its borders, but before the Baltimore and Ohio was ten years old, attempts were made to provide rail transportation in Texas, and in 1840 slave labor began actual construction work. This particular project was temporarily abandoned in 1841, but reopened in 1850. By 1856 two miles of line were completed, and by 1860 it extended north from Houston to Millican, a distance of 80 miles. Millican remained its terminus until after the War of Secession.

LITTLE TRAFFIC ON EARLY ROADS

It was the desire to grow, not the actual growth, which prompted these attempts at railroad building. Neither population concentration nor wealth justified this or any other early efforts. Yet there were 11 companies operating something less than 500 miles of track at the outbreak of the War of Secession, and more than 50 companies had been chartered. The war caused the bankruptcy of these early companies; 53 miles of line were destroyed, and two companies with 161 miles abandoned operations. They remained bankrupt until about 1870, and the largest line, the Texas and New Orleans Railroad, was not rehabilitated until 1876.

With the readmission of Texas to the Union in 1870, an era of rapid expansion of railroads began, and railroad mileage increased from about 500 miles in 1870 to 8,654 in 1890 (more than half its present mileage). From the original chartering of a state railroad by the Republic in 1836, to the adoption of the constitution of 1876, the attitude of government was favorable, although the desire for cheap transportation and the regulation of charges was clearly evidenced. The second charter granted by the Republic of Texas, which in 1838 gave its congress the sole right to regulate the rates of tolls, incorporated maximum charges for both freight and passengers, and in 1853 the state prescribed maximum freight and passenger fares by law.

The predominant public policy was one of rapid settlement of the large domain. Immigration was encouraged. Concessions which, seen from today's viewpoint, seem most liberal, were granted to the early railroad companies to encourage construction. Direct aid was granted under a law of 1856, which authorized the state to loan a part of its public-school funds for railroad construction. Loans up to $6,000 per mile of completed track at 6 per cent interest and 2 per cent for sinking fund were permitted, and nearly two million dollars was loaned before the War of Secession.

In 1866 the state was authorized to guarantee railroad bonds up to $15,000 per mile, but this authority was never used and was omitted from the reconstruction constitution of 1869. In 1871 a law was passed giving cities, towns, and counties the right to donate or subscribe to the capital issues of railroad companies to encourage construction, but this was repealed in 1874 under pressure from farm blocs.

LAND GRANTS TO RAILROADS

From 1852 to 1882 there were five distinct periods as regards the issuance of land grants to aid railroad construction. These included two periods of special acts, two periods of general acts, and one period of prohibition (1869–1873) under the reconstruction constitution. Public lands equal to an area larger than Indiana were granted to the railroads under these acts. It is said that 41 companies patented 35,768,710 acres, of which the railroads actually received 24,453,000, or about 38,000 sq miles. These grants generally required alienation of title or reversion within a period of five years, and the railroads were themselves required to survey and stake out not only the lands granted but the alternate sections as well. This land policy was a liberal one in more ways than

A SECTION OF THE HOUSTON SHIP CHANNEL
Showing Shipping Facilities, Railroad Terminal Tracks, and Industrial Buildings

one, and by the time it was discontinued in 1882 the state had actually issued certificates of land grants for eight million acres more than it possessed!

It was during the period of the land-grant policy that the era of transcontinental railroad building began, both in Texas and elsewhere. The Missouri, Kansas, and Texas Lines were the first to enter Texas from the north (there were some connections across the eastern border before that time). This railroad had its inception in the military necessities of the nation and was developed to connect Forts Leavenworth and Riley on the north with Forts Sam Houston at San Antonio and Crockett at Galveston on the south, tying in service with Fort Gibson in Indian Territory.

The mad scramble of the state to dispose of its public lands, and of the railroads to sell or develop theirs before the expiration of alienation dates, depressed the value of farm lands. In consequence, the State Grange in 1872 (the year the Houston and Texas Central Railroad arrived there from Millican) held a meeting in Dallas, from which grew an organized demand for strict control of the railroads and a check to their political power. The new constitution, written during the fall of 1875 and adopted early the next year, contained a program of railroad regulation, requiring all Texas railroads to maintain headquarters in the state. Railroad regulation did not become effective, however, until 1891, when the Texas Railroad Commission was created, with full powers to regulate rates, services, and many railroad operations. This regulation did not hinder the spreading of railroad lines over the state, however.

With the adoption of the constitution of 1876, reconstruction days were over in Texas. Essentially the state remained a land of cotton and of cattle until the turn of the century, but the merging of small railroads into systems and the construction of new lines continued after the adoption of the constitution. The peak of new building was reached in 1881, when 1,669 miles of track was laid, making 4,000 miles in all. In 1882 the land-grant policy of subsidy was dropped, but construction did not stop. In fact, the total mileage of the state was doubled from 1882 to 1889, by which time a network of lines, north to south and east to west, had been completed across the vast area of the state. In the decade from 1890 to 1900 the entire new rail mileage built was less than in the single year of 1881, but the century closed with nearly 10,000 miles in operation.

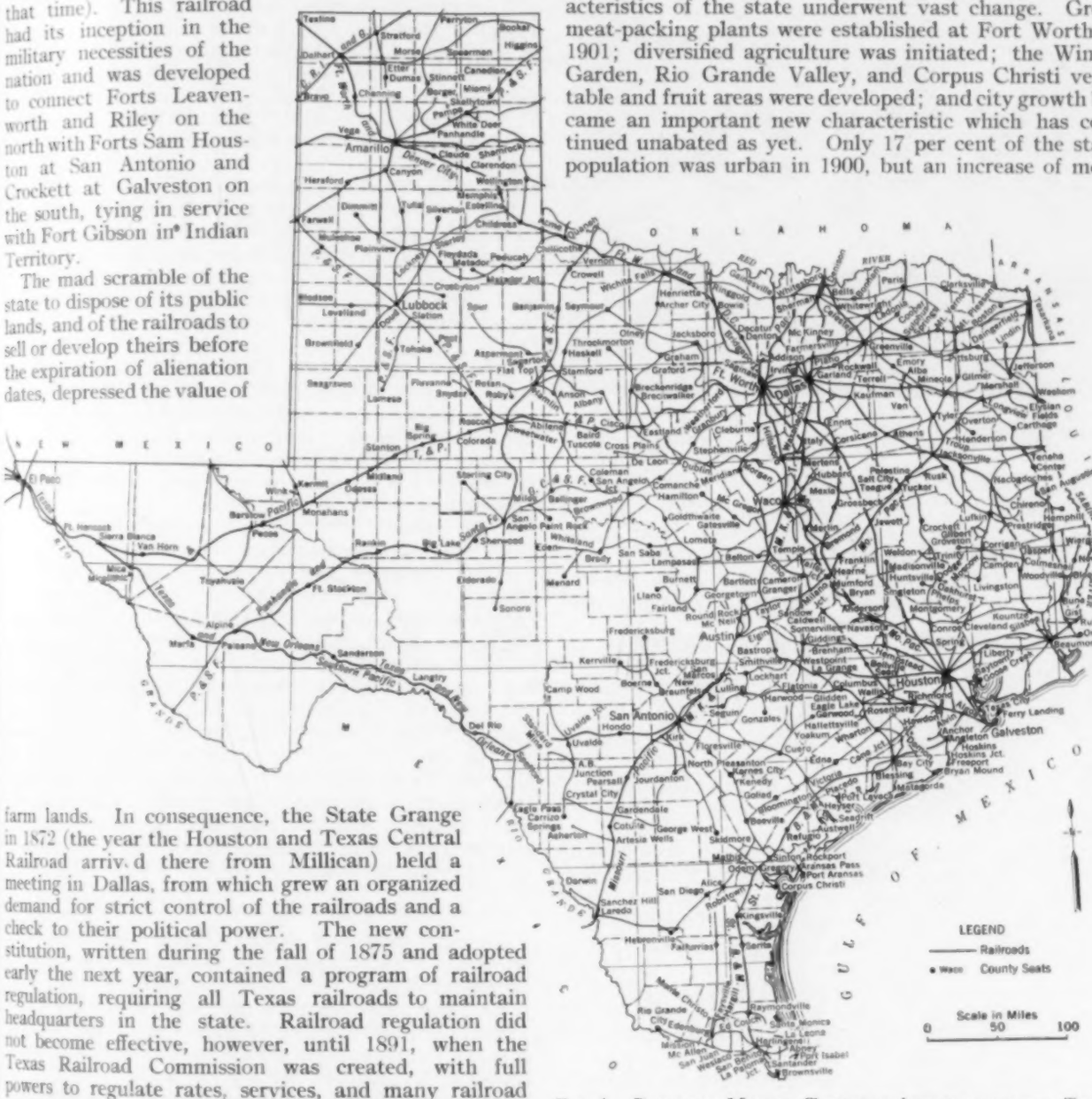


FIG. 1. RAILROAD MAP OF TEXAS AS APPROVED BY THE TEXAS PLANNING BOARD IN 1935

CITY GROWTH BECOMES IMPORTANT

Following the turn of the century, the economic characteristics of the state underwent vast change. Great meat-packing plants were established at Fort Worth in 1901; diversified agriculture was initiated; the Winter Garden, Rio Grande Valley, and Corpus Christi vegetable and fruit areas were developed; and city growth became an important new characteristic which has continued unabated as yet. Only 17 per cent of the state population was urban in 1900, but an increase of more than 400,000 in the cities brought the ratio to 24.1 per cent in 1910. From this point it has steadily grown until in the last census it reached 41 per cent. It is probable that the next census, in 1940, will show a nearly even distribution between city and country for the nearly seven million people who will than inhabit Texas.

The first important discovery of oil in Texas (Spindletop) occurred in 1901. Nine years later the first long-distance pipe line for natural gas was completed from Clay County to Dallas and Fort Worth. Finally the Panhandle field was opened with gas enough to supply

all of Texas for a long time to come. With more prosperous cities, attention was turned to port development, and the monopoly long enjoyed by Galveston came to an end. Houston, Corpus Christi, and Ports Isabel and Brownsville now vie with natural Port Arthur for the future distribution of the tonnage.

MODERN RAILROAD TERMINAL AND ROUNDHOUSE OF THE MISSOURI-KANSAS-TEXAS LINES AT FORT WORTH

The second and third periods of Texas history referred to previously are not eras of marked political consequence, but of civilizing influences at work under a stabilized government. Were I speaking of broader economic factors than railroads alone, I would feel no occasion for describing a fourth period. But in fairness to the subject it cannot be overlooked.

This fourth period, which still continues, may be dated with, but is not largely a result of, the discovery of gas in the Panhandle. It is an era of stagnation in which railroad mileage has actually decreased, and revenues have shown no great gains. Three primary factors have brought about that change: Natural gas, pipe lines for the transportation of petroleum and its products, and (particularly) the development of the automobile.

Gas is now transported out of the state to such distant cities as Monterrey (Mexico), Denver, Kansas City, Chicago, and very recently to Detroit. The use of gas as fuel for power and heating has deprived the coal-carrying roads of enormous tonnages and greatly reduced their revenues, although it has aided in the industrialization of the state. Today natural gas is served to more than two million people in Texas by more than 100 operating companies with 12,500 miles of transportation lines within the state.

Petroleum, like gas, has contributed both adversely and favorably to railroad development. As fuel it has displaced coal, particularly in the heavy tonnages formerly loaded into ships' bunkers at seaports. Crude oil does not generally travel by rail, but many of its products do. Prevented by regulation from making low train-load rates to large train-load shippers, and not being permitted to develop off-peak charges for freight service, the railroads were obliged to stand by while the oil industry developed a cheaper mode of transportation through the construction of pipe lines. Today pipeline investment in Texas exceeds that of the railroads. Detailed statistics are not public, but it is known that Texas pipe lines handled 544,646,364 bbl of oil, or 104,938,163 tons, in 1935, which was a greater tonnage than was ever handled in a single year by all the railroads of Texas combined. Unduplicated shipments amounted to 412 million barrels, of which 375 million came from leases and 65 million from outside the state. Production figures indicate that less than one million barrels produced in the state did not move by pipe line.

PETROLEUM PIPE LINES CARRY GREAT TONNAGES

Total pipe-line mileage is nearly $2^1/_3$ times total rail mileage. It also appears that the pipe lines of Texas in 1934 performed a total petroleum transportation service equal to more than 50 Missouri-Kansas-Texas railroads. Furthermore the total ton-miles of revenue freight for all railroads in Texas for 1934 was 8,513,130,106, only a little more than double that of an everage one among 26 pipe lines, and the pipe lines are therefore performing 13 times as much transportation service as all the railroads!

But whereas natural gas and petroleum have stimulated development of the state as a whole, and have themselves contributed tonnages to the railroads—in the form of raw and finished products, refinery and field equipment, and pipe—highway transport has not so clearly mixed blessings with its competition. The survey of trucking recently completed by the U. S. Census of Business shows for Texas 5,393 vehicles, receiving revenues in excess of $15,500,000. This is equivalent to one truck for hire for each three miles of railway track, and means a gross freight revenue loss of 17 per cent. Considering only long-distance hauling, there is one truck for every 5.9 miles and a revenue loss of 11.6 per cent of present railroad freight earnings.

From 1926 to 1935, motor trucks of all kinds registered in Texas increased from 104,000 to 257,000, or 146 per cent; whereas railroad mileage increased less than 600, under 4 per cent. In the same period railroad freight revenue per mile of railroad was reduced more than one-half and passenger revenue fell off two-thirds. We need not strain our imaginations to assume that each truck in Texas might increase its transport service by $1.01 per day, measured in terms of railroad freight charges. But it would be a terrific strain to imagine that all the railroads of Texas had no freight revenue at all. The two assumptions, however, make an equation. It is true, of course, that a large part of these trucks are not competing with the railroads, but many of them furnish transportation services which were formerly provided by the railroads.

HIGHWAY TRANSPORT NOT REGULATED

For more than sixty years the State Constitution has provided for the regulation of the railroads as common carriers, and such regulation has been effective for 46 years. But that regulation was not designed to prevent competition, nor can the railroads ever assume that regulation will spread quickly or equally to other forms of transportation as they develop.

However, even if there were eventually equality of regulation there would still remain such vast inequalities in operating economies as rent-free, publicly operated, and tax-free terminal facilities for aircraft and waterborne vessels, and free or nearly free use of public rights of way for highway transport. The imposition of safety requirements and regulation as to rates of pay, hours of work, minimum crews, and union working rules, are a few examples of obligations enforced almost exclusively upon railroads.

The truck laws of Texas are considered by many the most effective in the nation; yet I believe the foregoing analysis is sufficient to show the hazard for the railroads. These constituted a large resource in the early develop-

ment of the state, and are still an important and essential part in the economic life of the state, both as taxpayers and as buyers of Texas-produced goods.

The Missouri-Kansas-Texas Line expects to increase its efforts to further the development of the state. Only by such development, and the resulting increased movement of goods and people, can we expect to restore our revenues even to the level of twenty-years ago, unless economic forces and regulating powers are applied equally among the various transportation agencies, letting each take its proper place, where it can render a maximum service at minimum cost.

Even now, with equality of opportunity, our railroads could be prosperous. The degree of our prosperity will continue to mark, to some extent, the growth of the state of Texas.

Texas Industries—Present and Future

By W. B. TUTTLE

CHAIRMAN OF THE BOARD, SAN ANTONIO PUBLIC SERVICE COMPANY, SAN ANTONIO, TEX.

THE effects of the industrial development of Texas and the desirability of concentrated endeavor by engineers to bring about increases in such development, with corresponding benefits, can perhaps best be illustrated by reference to the chart (Fig. 1). This shows certain statistical data for Texas from 1900 to 1936, and gives information on population, effective purchasing power, value of crops and livestock products, value of mineral products, and value of manufactured products. The figures shown in the chart for the last five years are in part estimates.

It will be noted that the population has increased steadily, and that the purchasing power has closely followed the increase in population up to 1930. While purchasing power declined about 15 per cent during the depression, there was a 50 per cent drop in the value of crop and livestock products, formerly the main source of income in the state. The increase in the value of mineral and manufactured products, or in other words industrial development, apparently prevented a most serious economic condition between 1930 and 1935.

Asphalt Rock.—The value of asphalt rock produced in the United States in 1934 was $2,365,750. Texas produced in the same year asphalt rock to the value of $173,937. The figures for Texas for 1935 are not available.

The only rock asphalt now being used in Texas occurs in Uvalde and Montague counties. However, it also occurs in the sands and sandy shales of the Jackson formation of the Eocene era, and is generally distributed in the Trinity sands which occur in a number of localities (Fig. 2). From the east line of Kinney County through the county extends the largest deposit of bituminous limestone known. This deposit has no rival except possibly in the Lebanon region of Syria.

Barite (*Barytes*) is also known as heavy spar. Texas did not produce barite in 1935, and 57 per cent of the amount produced in the United States came from Missouri. Barite is known to exist in commercial quantities in several counties of Texas.

Celestite is a heavy, white or bluish mineral resembling barite. There has been little or no work on celestite in the United States since the World War, and a great proportion of the supply is furnished to this country by Great Britain and Germany. Celestite is reported in several counties of Texas, and prospects in some localities encourage the possibility of commercial deposits.

Coal (*Bituminous*).—It is reported that in Texas there is a workable area of 8,200 sq miles of coal, with an additional area of 5,300 sq miles that may contain seams. The original supply of coal, as given by the *University of Texas Bulletin No. 3401*, was about eight billion tons.

Copper is found in many counties of Texas. In the Quitman Mountains of West Texas there are copper, silver, and zinc ores of the Tertiary Age. Pre-Cambrian copper ores, in places carrying silver, are found in the central mining district; copper carbonates occur in fissure veins of the Permian Age in the Guadalupe Mountains in Culberson County; copper sulfides and carbonates are found in a number of places in the pre-Cambrian rocks of the Llano uplift, Central Texas; and copper occurs in the red-beds of the Permian Age in a number of counties in the northern part of Texas.

According to the U. S. Bureau of Mines, Texas in 1936 produced 52,000 lb of copper valued at about $4,784. Because of the rapid rise of the price of copper in 1937, several new mines in West Texas are being operated with an appreciable output.

Dolomite, a calcium-magnesium carbonate, is also known as pearl spar and magnesium limestone. No production is reported for Texas for 1934. However, a large Louisiana Company has acquired an extensive area of dolomite in Burnet County for the manufacture of magnesium. Also, some dolomite has been used to manufacture terrazzo chips.

Feldspar is not the name of any one mineral, but of the commonest group of rock-forming minerals. The feldspars considered here are only those that are used in ceramics and other manufacturing. These are known to the trade as "potash" feldspar and "sodium" feldspar. No production of feldspar is reported, although a small amount is mined in Llano County and shipped to Mexico.

Fluorspar is a moderately hard, glassy, transparent or, translucent mineral. It is reported that commercial deposits exist in several counties in Texas. None was reported as having been produced in that state in 1935.

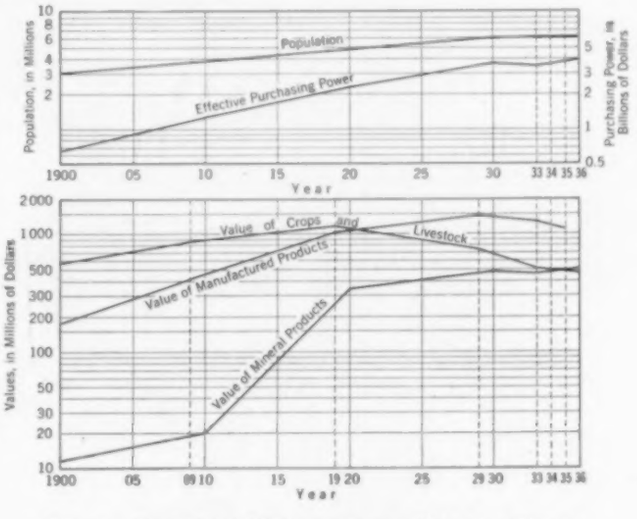


FIG. 1. STATISTICAL CHART FOR THE STATE OF TEXAS, 1900 TO 1936

Garnet is the name given to a group of minerals of similar physical properties and crystal habit. At least seven varieties have been recognized in Texas, but only those used for abrasive purposes are considered in these notes. No report of 1935 production is available.

Granite.—These notes deal only with the granites that are used for building stone and ornamental purposes. Granites of good commercial quality and quantity are found in several locations in Texas (Fig. 3). While recent figures are not available, a large movement continued throughout the year 1936.

In Llano County there are large deposits of a porphyry known as "opaline" granite. While this stone is very hard, it is regarded as a very handsome rock and takes a fine polish. It contains an inclusion of bluish quartz in small oval pieces.

General Clays.—Texas possesses workable supplies of all kinds of clay except ball clay. However, some of the fuller's earth and bentonite may be found suitable substitutes for ball clay. Since the state has the largest supply of natural gas, which is a very suitable fuel for the manufacturing of clay products, the clay industry should become important there. In 1935 Texas produced $261,623 worth of commercial clays.

Graphite, the final metamorphic stage of all carbon minerals, is reported in several locations in Texas. The Southwestern Consolidated Graphite Company, which has a large mill a few miles west of Burnet, Tex., reports that it will soon be producing crystalline graphite for the market. Another property is being opened up west of Burnet for the production of crystalline graphite.

Gypsum occurs in Texas in selenite, a transparent cleavable form; satin spar, a fibrous silky form; alabaster, a massive, fine-grained variety; rock gypsum, a compact, granular form; and gypsite, an earthy, soft, impure variety. Gypsum is found in many places in Texas, and there are five gypsum plants operating in the state. In 1934, the value of gypsum produced in Texas was $1,403,454.

Iron Ore.—There are three types of iron ores in Texas —namely, residual sedimentary ores in the Llano uplift, supposed residual or lateritic hydrated ores in East Texas, and contact metamorphic deposits in limestone in West Texas. There was once a flourishing iron industry in the state, but lack of nearby coal for coke manufacture has been given as the reason for discontinuance. Study is now being made of possible practical methods for the manufacture of wrought-iron and mild steel from East Texas iron and natural gas.

Lead is reported in many sections of Texas. In some localities the deposits are apparently of commercial quality and quantity. The U. S. Bureau of Mines reports that in 1936 Texas produced 1,049,000 lb of lead with an approximate value of $48,254. Since the market price of lead has increased, a great deal more lead is being produced, and the opening of new mines is contemplated.

Lignite is a variety of coal intermediate between peat and bituminous coal. It is also called brown coal and wood coal. The *University of Texas Bulletin No. 3401* states that the workable area of lignite in Texas is estimated at 50,000 sq miles, with a possible additional area of 10,000 sq miles, or a total of 60,000 sq miles. The original supply of lignite was estimated at 30 billion tons. Lignite is found over a wide area of the state. However, due to the widespread use of natural gas only a few mines are working.

Limestone, when pure, consists of calcium carbonate in either the amorphous or crystalline form. It is found over a large area of Texas (Fig. 4). There are reported producers of limestone for its various uses in Grayson, Hardeman, Harris, Lampasas, Travis, and Williamson counties. The principal commercial uses of limestone are as building stone and for the manufacture of lime.

Manganese has one principal ore, pyrolusite. Other forms of oxides are braunite, hausmannite, and psilomelane. It is reported that there are deposits of manganese in several counties of Texas, but the three noteworthy deposits of this mineral are the Spiller Mine in northeastern Mason County, the Walter Mayfield deposit in southwestern Jeff Davis County, and the deposit near Shumla and Feely in west Val Verde County. Texas did not produce this mineral in 1935.

Marble is a crystalline rock formed by the metamorphism of limestone or dolomite. There are some very fine and extensive deposits of marble in Texas (Fig. 5). Samples of Texas marbles from commercial deposits show many stones of excellent quality, and wide diversity of colors, banding, and textures. Marble is used for cut stone, mill block, marble dust, slabs, and monuments.

Mercury, commonly known as "quicksilver," is a very heavy, silver-white mineral, which is generally found in Texas as the sulfide, cinnabar. In 1935 the value of mercury produced in Texas was $301,710. Due to the present civil war in Spain and the consequent rise in

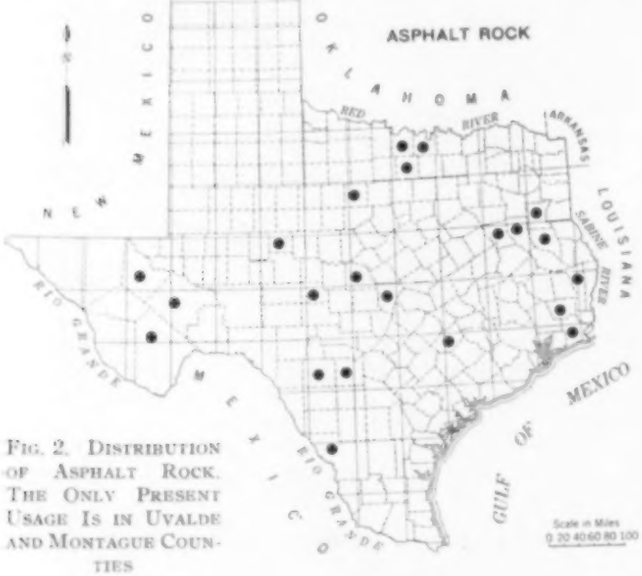


FIG. 2. DISTRIBUTION OF ASPHALT ROCK. THE ONLY PRESENT USAGE IS IN UVALDE AND MONTAGUE COUNTIES

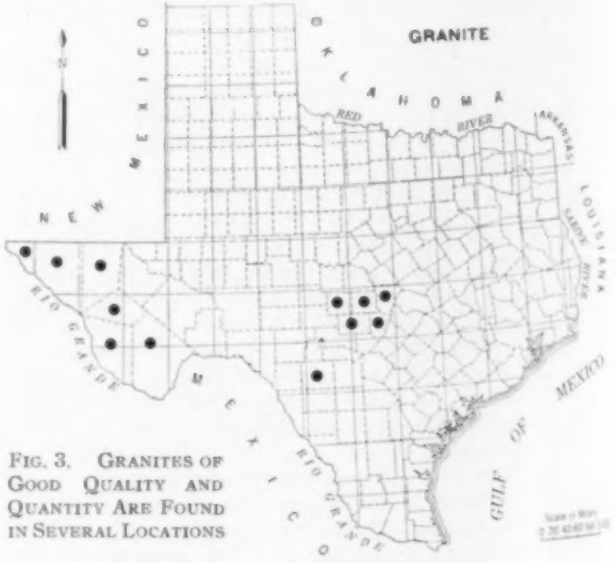


FIG. 3. GRANITES OF GOOD QUALITY AND QUANTITY ARE FOUND IN SEVERAL LOCATIONS

price, the output for Texas has had a very large increase in 1936 and early 1937. The 1935 average price was quoted as $73.87 per 76-lb flask, and *Engineering and Mining Journal* for March 1937 quotes quicksilver at $92 per 76-lb flask in shipments of 100 flasks or more.

Potash is economically a very important mineral. The sources and the methods of production are so numerous and diversified that literature on the subject is very extensive. A large proportion of the sources of potash in the state are the buried soluble salts of potassium in the Permian basin, and a great deal of work has been done in prospecting these deposits and developing methods of refining these underground soluble salts. The main interest attaches to a bed of polyhalite 5 ft or more thick.

Pumice and Pumicite.—Pumice is a highly vesicular or cellular, glassy, volcanic lava, usually rhyolitic in composition. Pumicite, or volcanic ash, is a more or less finely divided powder or dust made up of small, sharp, angular grains of volcanic glass of about the same composition as pumice. Pumicite is found over a wide area in Texas, and several plants are active in its production.

Salt is halite, or sodium chloride, and is known to exist in commercial quantities in many Texas counties. Refined salt is being produced in Harris, Henderson, Lynn, Nueces, and Van Zandt counties. In 1935 Texas produced evaporated and rock salt valued at $391,424.

Silica.—Under this head only the quartz sands and sandstones that are used for abrasives, refractories, chemical industries, ceramics, and glass manufacture are considered. Silica, or silicon dioxide, occurs in a free state, chiefly as quartz. Although sand is common in most parts of Texas, sandstone suitable for abrasives is apparently rare east of the Pecos River.

According to *University of Texas Bulletin No. 3401*, an apparently excellent sandstone for an abrasive occurs in the Smithwick formation of the Pennsylvanian Age; the Bliss sandstone in the Franklin Mountains; the carboniferous Tesnus and Haymond sandstone in the Marathon Basin; and the Permian Alta sandstones in the upper Cibolo Creek basin; and possibly some sandstones and siliceous shales of the Permian Delaware Mountain and Word formations of the Delaware and Glass Mountains. Also, possible commercial materials occur in the Cox, Campagrande, Etholen, and Maxon formations of the Cretaceous Trinity Age, the Walnut of the Fredericksburg, and the Washita of the Del Rio formations. Several commercial deposits of glass sand suitable for the manufacture of white and colored glass are found in Texas.

Silver.—On January 19, 1937, the U. S. Bureau of Mines reported that from 1885 to 1936, inclusive, Texas produced 26,012,507 oz of silver. This mineral is reported as existing in a number of counties in Texas, and silver to the value of $719,440 was produced in the state in 1935. Records show that in 1936 there were eight producers of silver in Texas, but due to the rise in price of the metal in that year many old mines have been opened up and new ones put into production.

Sulfur as catalogued here deals only with the underground sulfur and not the potential sulfur supply from pyrites. It is found in porous limestone above several salt domes in the Texas coastal area. The process of recovery of sulfur by the use of superheated water and compressed air produces a sulfur, reclaimed from underground, that is practically 100 per cent pure. Texas produced $24,854,810 worth of sulfur from underground sources in 1935.

Talc and Soapstone.—Some talc is present in all real soapstones, and there is a similarity in the uses of both substances. Talc usually occurs in soft, foliated, and compact massive aggregates, white, gray, or green in color. Soapstone is green or grayish-green. Talcs are known under the trade names of asbestine, agalite, talclay, verdolite, and mineral pulp. Talc and soapstone are reported in several counties, and while there has been little or no production of this mineral in Texas, many of the deposits merit investigation.

Cotton.—The Texas cotton crop for 1936, exclusive of linters, as reported by the Bureau of the Census on March 20, 1937, was 2,939,573 bales with a weight equivalent to 500 lb each. This represents 23.7 per cent of the cotton produced in the United States in 1936. At a price of 11.5 cents per lb, which was the average price received by Texas farmers on December 15, 1936, the Texas crop, if entirely sold, would bring its producers $169,025,000. In addition to this sum, the sale of the cottonseed, estimated at 1,318,000 tons, if entirely sold at $33 per ton, would increase the sum by $43,494,000.

The Texas Almanac for 1937 states that only 2 or 3 per cent of the Texas cotton production is manufactured in that state. For 1936 this is equivalent to 58,790 bales.

Wool.—On August 10, 1936, the Texas office of the Bureau of Agricultural Economics estimated that Texas would produce 63,167,000 lb of wool, or 17.4 per cent of the total amount produced in the United States. In

FIG. 4. LIMESTONE IS FOUND OVER A LARGE AREA

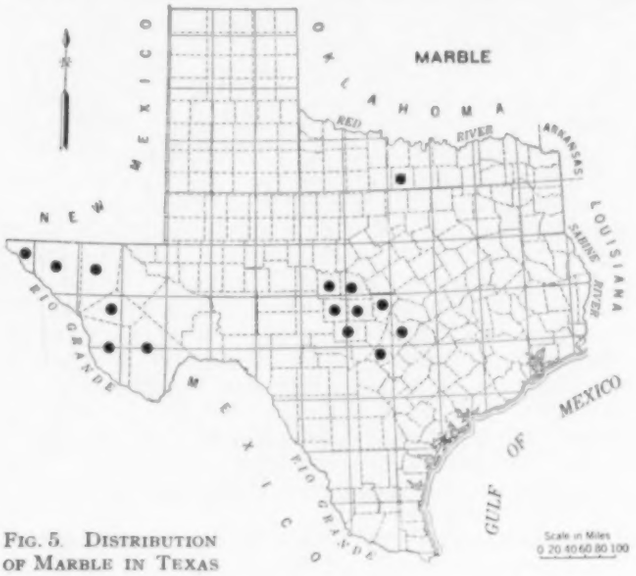


FIG. 5. DISTRIBUTION OF MARBLE IN TEXAS

Fig. 6 are shown the areas principally devoted to the production of wool. At 30 cents per lb, the average price received by Texas farmers on December 15, 1936, the Texas wool clip for 1936 was worth $18,950,100. This was for the wool in the grease and unscoured. Since there are no scouring mills or woolen mills in Texas at this time, this entire quantity is shipped to the industrial East via boat from either Houston or Galveston.

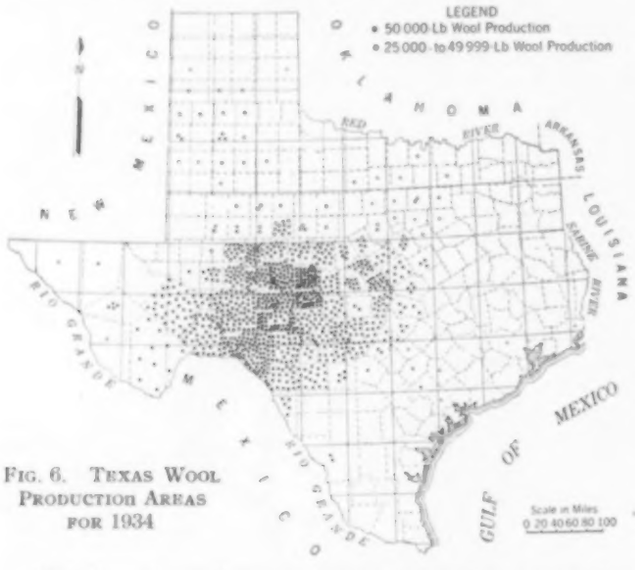


FIG. 6. TEXAS WOOL PRODUCTION AREAS FOR 1934

Mohair.—According to a report from the Texas office of the Bureau of Agricultural Economics, issued on March 16, 1937, Texas produced 13,400,000 lb of mohair and kid hair in 1936. This represents approximately 84 per cent of the entire mohair clip in the United States. At an estimated value of 56 cents per lb, the total value of the 1936 Texas mohair clip was $7,504,000.

Cattle.—The Texas office of the Bureau of Agricultural Economics reported that on January 1, 1937, there were 7,547,000 head of cattle on farms and ranches, valued at $164,690,000. This represents 11.3 per cent of all the cattle in the United States on that date. In Fig. 7 is shown the distribution of Texas cattle and calves as of January 1, 1935.

Texas produces grains and forage crops. Consequently, to secure the highest returns from the cattle industry, the state should feed, fatten, and slaughter cattle, and should then ship the surplus meats to the densely populated areas, either by rail or by boat. The hides should be tanned in the state to supply the demand of Texas and adjacent states for bulk leather. Likewise, other materials resulting from the slaughter of cattle should be processed in Texas for the local demand.

There is a considerable demand for milk products. With the large number of milch cows in the state, and the opportunities that exist for the further improvement of herds, Texas should process additional milk supplies.

Forest Products.—The East Texas timber belt has an area of 12,624,000 acres, of which 10,615,000 are of the pine type, and 2,009,000 acres of the hardwood type. The estimated cut in 1935 was 650,000,000 board ft, of which 509,788,000 ft was yellow pine, as reported by 381 saw mills. In normal years the annual value of Texas planing mill products is upward of $12,000,000, and of the box and crate industry upward of $3,000,000. The lumber industry itself produces values between $40,000,000 and $45,000,000.

Railroads.—The World Almanac for 1936 states that Texas now leads in railroad mileage, having 16,892 miles in 1934. The Texas Almanac gives the state 16,661 miles of main-line track at the beginning of 1935, with a total of 22,937 miles of tracks of all kinds.

Electric Lines.—Texas is well served by electric transmission lines. There are approximately 18,000 miles of high voltage lines serving in excess of 1,500 cities, towns, and villages. Local distribution lines in cities and towns aggregate more than 12,000 miles. The generating capacity of Texas plants in 1935 was 958,651 kw, and the energy generated in the state was 2,938,000,000 kw hr.

Oil and Gas Pipe Lines.—Oil and gas pipe lines crisscross the state of Texas in several directions. The petroleum output for the state in February 1937 was 1,322,300 bbl daily. For January 1937, it amounted to 1,071,200 bbl daily. Consequently, Texas is producing one-third of the nation's supply of petroleum. The production of natural gas in Texas in 1936 amounted to 847,611,427,000 cu ft—the dry gas amounting to 578,520,916,000 cu ft, and casinghead gas to 269,090,511,000 cu ft.

Highways.—Texas has one of the best highway systems in the nation. On March 1, 1937, there was a total state highway mileage of 21,048 miles, of which 18,437 miles were improved highways.

Construction of highways is proceeding at a rapid rate in the state, and the average annual rate of construction over a period of nineteen years is 1,451 miles. During 1936, however, 2,543 miles of highway were completed, surpassing the average annual rate by 1,100 miles.

CONCLUSION

The Texas Planning Board has, as one of its principal objectives, made a study of the resources of the state and the possibilities for industrial development. Through the courtesy of Maj. E. A. Wood, director of the Planning Board, and his staff, I have been able to present the distribution of the potential mineral, agricultural, and timber resources available, as well as the available transportation, fuel, and power facilities.

The charts and statistical information presented show that Texas has vast possibilities for industrial development. Careful consideration of these possibilities will demonstrate that there are opportunities for valuable engineering service in many fields. Of course a detailed study of each field must be made before there can be a full understanding of the rôle of engineering in the development of industry.

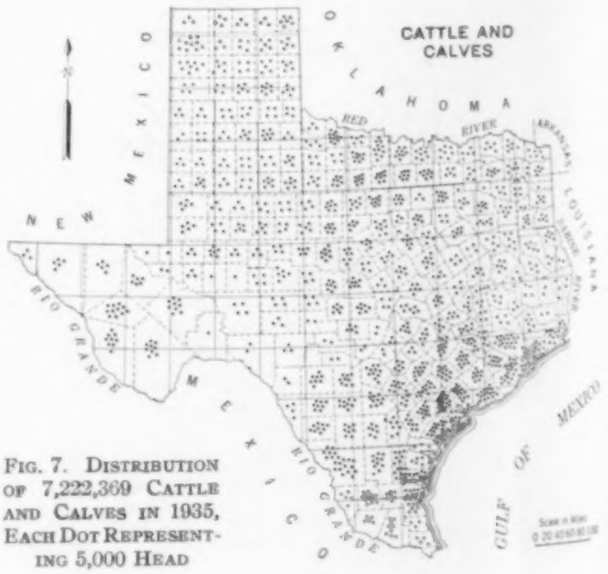


FIG. 7. DISTRIBUTION OF 7,222,369 CATTLE AND CALVES IN 1935, EACH DOT REPRESENTING 5,000 HEAD

Rectification of the Rio Grande

And Other Engineering Work of the International Boundary Commission, United States and Mexico

By L. M. LAWSON

MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS

COMMISSIONER OF THE UNITED STATES, INTERNATIONAL BOUNDARY COMMISSION, EL PASO, TEX.

BY the Gadsden Treaty of 1853 between the United States and Mexico, the "deepest channel" of the Rio Grande was fixed as the international boundary from El Paso to the Gulf. But gradual and avulsive changes have since occurred so frequently in that river that the Secretary of State, acting through the American boundary commissioner, was recently authorized by Congress to make studies leading to rectification of its channel in line with the provisions of the Treaty of 1933. The Mexican Section of the International Boundary Commission has made valuable contributions to this work, now well advanced, and has cooperated ably with the United States Section. Other activities of the Commission described herein are flood-control work on the lower Rio Grande and at Nogales; construction of a concrete diversion dam and connecting canal near El Paso; solution of international sanitation problems, notably on the Tijuana River; surveys along the international boundary including elimination of "bancos"; and collection of hydrographic data on the watershed of the Rio Grande. The article is abstracted from Mr. Lawson's address of April 22, 1937, before the Surveying and Mapping Division at the San Antonio Meeting of the Society.

THE two thousand-mile international boundary line between the United States and Mexico traverses an area abounding in questions of both internal and international importance. The Colorado and the Rio Grande, both rising in the Rocky Mountains, are the main sources of water supply in the area. The former crosses the boundary line but forms the boundary itself for only 20 miles, whereas the Rio Grande constitutes the boundary for nearly 1,300 miles.

With a river boundary line and one source of water supply, the interests of the two peoples are the same in problems of flood control, irrigation, and sanitation. Many problems of the border had long depended upon international agreement or treaty for their adjustment or solution, and border communities thus were kept waiting for remedial and beneficial works already enjoyed by interior localities. In 1905 the break of the Colorado River through Mexican territory into the Salton Sea in the United States accentuated the necessity for international engineering consideration of these mutual problems.

The international boundary was fixed initially by the Treaty of 1848 and the Gadsden Treaty of 1853. The Treaty of 1853 fixed two water boundaries—the deepest channel of the Rio Grande from its mouth to a point near El Paso, Tex., and of the Colorado River from a point near Yuma, Ariz., extending approximately 20 miles downstream. Soon it became apparent that characteristic changes in the channels of these rivers would inevitably create difficulties. The boundary convention of 1884 then adopted the principle that in the case of changes wrought by gradual erosion the river would continue to be the boundary, but in the case of changes wrought by avulsion the boundary would remain in the abandoned river bed.

The Treaty of 1889 established an International Boundary Commission, to have exclusive jurisdiction in the case of such differences or questions as might arise. Experience soon indicated that the rule under the 1884 treaty was not practicable, as avulsive changes, which occurred frequently, isolated parcels of land from the country exercising jurisdiction over them, with attendant difficulty in administration. To meet this condition the Treaty of 1905 provided that, by joint action of the Commission, certain parcels which might be segregated by avulsive river changes might be exempted from the effects of the Treaty of 1884. The Treaty of 1933 provided for the rectification of the Rio Grande in the El Paso-Juarez Valley, as hereinafter described.

The conduct of engineering projects along the boundary was facilitated by an Act of Congress approved August 19, 1935. This act authorized the Secretary of State, acting through the American boundary commissioner, to conduct technical and other investigations relating to the defining, demarcation, fencing, and monumentation of the land and water boundary between the United States and Mexico, to flood control, water resources, conservation, and utilization of water, sanitation and prevention of pollution, channel rectification and stabilization, and other related matters. Various projects undertaken by the Commission under the powers thus granted are indicated on the general map of the international boundary line, Fig. 1.

The Treaty of 1933 provided for straightening the Rio Grande through the El Paso-Juarez Valley, from El Paso to the head of Box Canyon, also confining the rectified

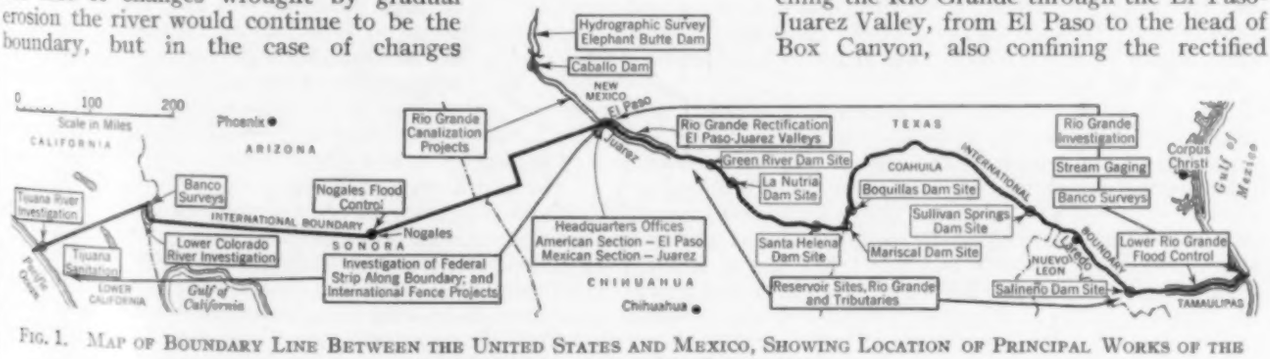
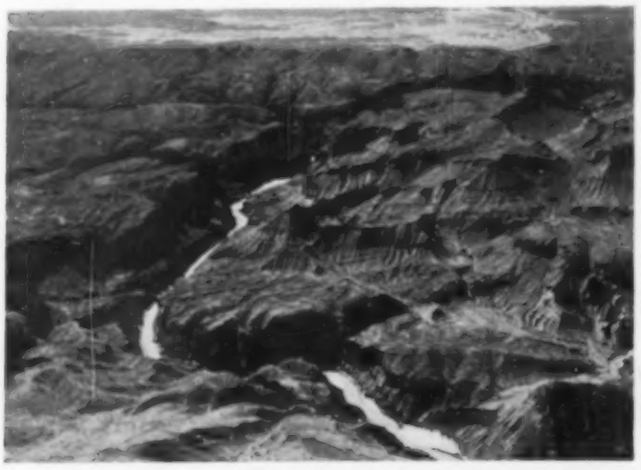


FIG. 1. MAP OF BOUNDARY LINE BETWEEN THE UNITED STATES AND MEXICO, SHOWING LOCATION OF PRINCIPAL WORKS OF THE INTERNATIONAL BOUNDARY COMMISSION

channel between two parallel levees and decreasing its length from 155 to 88 miles. (A general plan of part of this area is shown in Fig. 2.) It also provided for construction of a retention dam at Caballo, N.Mex., about 100 miles above El Paso.

RIO GRANDE RECTIFICATION PROJECT

Although construction of the Elephant Butte Dam has considerably reduced the amount of sediment carried through the El Paso-Juarez Valley, the absence of the



BOQUILLAS CANYON ON THE RIO GRANDE, LOOKING DOWNSTREAM

former large scouring floods resulted in silting up and elevating the meandering river channel to a point where rainfall discharges from arroyos menaced El Paso, Juarez, and the valley lands.

Under these circumstances over $750,000 had been expended in a few years by the Mexican Department of Communications and Public Works and the City and County of El Paso for flood protection. The levees constructed required constant strengthening and repair on account of the raising of the river bed. The two communities affected soon expended all justifiable funds for local flood protection works, and it became clear that the only sound plan for accomplishing the desired results lay in a coordinated international project.

The rectification project of the Commission involved an estimated cost of $6,000,000, including Caballo Dam. It embodied the principles of two different schools of thought—a straightened channel between levees, and a retention dam. Construction began shortly after ratification of the Treaty of 1933, and the project is now about 80 per cent completed.

Since straightening of the channel would involve detaching areas from one side of the river and attaching them to the other, it was necessary to so locate the rectified river that the areas cut off from one country would equal exactly those areas cut off from the other. (Each government acquired the private titles to the lands required for the exchange.)

The normal flow of the river is carried in a pilot channel with a bottom width of 66 ft (20 meters). The levees on either side of this channel, however, are spaced 590 ft (180 meters) apart, making a floodway that will accommodate discharges of 11,000 cu ft per sec (314 cu meters per sec). The gradient of the river is increased from a slope of 0.00035 (1.82 ft per mile) to that of 0.00061 (3.20 ft per mile). The lowered river grade caused scouring and deepening of the new channel and also resulted in lowering the ground-water levels.

Careful studies based on past floods showed that reduction of the flood flow reaching the El Paso-Juarez Valley through construction of a storage reservoir would make possible an estimated saving of $1,480,000 in the valley works required, through decreasing the size of the channel, the area required for right of way, yardage in levees, the length of grade-control structures and bridges, the amount of clearing, and overhead. The cost of an earth-fill Caballo Dam would thus be offset by the economies made possible, and the Boundary Commission set aside $1,500,000 for its construction with a reservoir capacity of 100,000 acre-ft.

However, many citizens desired a larger dam, to be subsidiary to Elephant Butte Dam in the production of hydroelectric power. Finally the Bureau of Reclamation undertook to construct such a dam at Caballo with a reservoir capacity of 350,000 acre-ft, at an estimated cost of $2,500,000 towards which the International Boundary Commission contributed $1,500,000. This dam is now under construction.

Many benefits, both physical and political, will be derived from rectification of the Rio Grande from El Paso to Box Canyon below Fort Quitman. Such rectification will, among other things, eliminate the annual flood menace, make possible the most beneficial use of the irrigation supply and the better drainage of the irrigable lands, create sand-carrying velocities at normal low water stages in the river, and establish a definite boundary which can be maintained and thereby perpetuated.

Although some expenditures cannot be definitely reduced to annual costs, the rectification will probably effect an average annual saving of from $150,000 to $250,000, in addition to the intangible but valuable political benefits and the value of flood storage in connection with the proposed Elephant Butte power development.

The project engineer in charge of the United States Section is C. M. Ainsworth, whose headquarters are at El Paso. He is assisted by Crawford S. Kerr as field engineer. J. C. Bustamante is consulting engineer for the Mexican Section, with headquarters at Juarez.

LOWER RIO GRANDE FLOOD-CONTROL PROJECT

The Rio Grande flows through the deltaic valley plain below the Big Bend district of Texas on a ridge formed by sediment from overflow and flood waters.

The Rio Grande drainage basin in the United States, between Fort Quitman and the Hidalgo County line, embraces an area of over 65,000 sq miles. The Mexican portion of this drainage area, between corresponding points, is over 78,000 sq miles. The growth of population, agriculture, and industry in this area is of such character that the control of floods constitutes a matter for national concern.

From above the Balcones Faultline to the coast, the watershed is subject to hurricane-type rains during the summer and early autumn, which produce dangerous flood conditions. A report of the American Section of the International Boundary Commission in December 1931, called attention to the serious flood situation, which existed in the lower Rio Grande Valley, and to the necessity for some agreement that would prevent international complications as a result of competitive levee building.

The first flood control works on the Lower Rio Grande, with the exception of certain small local levees along the river banks, had been the canal levees of irrigation enterprises constructed between 1902 and 1912. Many of these had been overtopped and destroyed in subsequent floods, but they showed that confining the flood discharge in one locality increased the overflow elsewhere. A modified plan of floodways was constructed in 1925 and 1926.

The present joint flood-control project contemplates, for the United States, the following features: raising and strengthening about 300 miles of river and floodway levees; clearing and grubbing about 150 miles of floodways; improvement of floodways by removal of obstructions or rectification of the channel; construction of protective works to prevent flood damage to important irrigation structures crossing the floodways, and to prevent the loss of existing river levees; and building structures to control the distribution of floodwaters between the floodways, or to prevent, during periods of medium high flows, the deposition of silt at floodway entrances. On the Mexican side, the joint plan includes similar raising and strengthening of the main river levee and improvement of floodways.

Consideration was given to the effect of storage on the main stream and its tributaries, but the area of the drainage territory below any feasible sites, the amount of recorded precipitation, and the expected spillway flow from storage reservoirs made it impossible to depend upon storage for the necessary protection. While definite flood flows were allocated to each country, the general principle was that each country should provide floodways for discharge that in the past had normally flowed through its territory.

Construction in the United States began in December 1933, under Public Works Administration allotments of $2,000,000. The total cost of the project is estimated to be $6,890,000. To December 1936, approximately 30 per cent of the project had been completed, and completion of the entire project is awaiting the transfer of sufficient rights of way to the government by donation. J. L. Lytel, M. Am. Soc. C.E., is in charge of the Lower Rio Grande flood-control project, with headquarters at San Benito, Tex.

Mexico began construction on its part of the flood control plan and has carried forward, up to the present, extensive work on the main river levee, floodway levees and channels, and various structures.

NOGALES FLOOD-CONTROL PROJECT

The twin cities of Nogales, Ariz., and Nogales, Sonora, are located on the international boundary line, approximately midway between El Paso and Yuma.

The Nogales Wash was originally the main drainage channel, flowing north through the centers of both cities. It had been walled in and covered through the business district in Nogales, Ariz., for some 2,200 ft north of the boundary, and was walled with masonry for some distance above and below the covered section referred to.

The Nogales Wash had proved entirely inadequate to handle the runoff caused by intense precipitation over the 26½ sq miles of mountainous drainage area south of the boundary. After the flood of August 1930, as conditions were such that neither city could solve the problem of flood control by itself, the problem was referred to the International Boundary Commission for study.

The joint plan developed by the Boundary Commission and approved by two governments provided for the construction of a new floodwater conduit through both cities, and the enlargement of the old Nogales Wash. The proposed works were planned to take care of an assumed maximum storm of a magnitude based upon past records. Each country is to bear the cost of the works to be located within its territory.

Work was started in December 1933, and is now completed. The new floodwater conduit was designed for a capacity of 6,500 cu ft per sec. It consists of 3,753 ft of masonry-lined trapezoidal section and 980 ft of closed conduit with masonry side walls and bottom and a reinforced-concrete roof slab. The trapezoidal section has a base width of 9 ft and is about 13 ft deep. Above the new conduit in Mexico, the old channel has been widened to provide a capacity of 8,500 cu ft per sec, and a special spillway structure will divert 2,000 cu ft per sec to the old channel.

Funds for the works constructed on the United States side were provided by PWA, the rights of way being furnished by the city of Nogales, Ariz. Work was commenced in November 1933, and completed in July 1936.

The project was divided into three units. The first consisted of 5,300 ft of floodwater conduit with a designed capacity of 6,500 cu ft per sec, extending northward from the international boundary line through the city of Nogales.

The second unit consisted of enlarging and lining with concrete about 3,000 ft of the old Nogales Wash, from the end of the existing closed conduit to its junction with Unit No. 1, to provide a designed capacity of 3,500 cu ft per sec. The third unit consisted of 3,400 ft of concrete-lined floodwater channel, having a designed capacity of 10,000 cu ft per sec, from the lower end of Unit No. 1 northward to the city limit. The lower 200 ft forms a stilling basin intended to dissipate a large part of the energy of the water, and thus limit the scour in the unimproved channel below.

The works constructed in the United States involved a total cost of $552,000, including handling 122,000 cu yd of excavation, placing 2,500,000 lb of reinforcing steel, and pouring 24,400 cu yd of concrete. The plans and specifications for the work were prepared in the El Paso office of the Commission. Col. S. F. Crecelius, M. Am. Soc. C.E., was project engineer in charge of the construction of Unit No. 1, and J. B. White was project engineer in charge of the construction of Units Nos. 2 and 3.

FIG. 2. PLAN OF A PART OF THE RIO GRANDE RECTIFICATION PROJECT, SHOWING AREAS TO BE SEGREGATED FROM ONE COUNTRY TO THE OTHER

THE AMERICAN DAM AND CANAL AND INTERNATIONAL SANITATION PROBLEMS

By the Convention of May 21, 1906, between the United States and Mexico, the United States was obligated to deliver to Mexico in the bed of the Rio Grande at El Paso, Tex., 60,000 acre-ft of water annually. The lack of facilities for the measurement and delivery

of a definite quantity of water to Mexico have made this requirement difficult to fulfill, and the United States Section of the Boundary Commission was authorized in February 1935 to determine the best means of complying with it.

An Engineering Advisory Board reported in November 1935 on the need for the proposed diversion dam and feeder canal. The dam is to be located just west of El Paso, a short distance above the point where the international boundary line intersects the river.

The design consists of a concrete diversion dam of the low-weir type with gates the entire width, and a concrete-lined canal connecting with the existing Franklin Canal, to be an open section in one part and a closed section elsewhere.

It is estimated that the diversion dam and connecting canal will cost $1,400,000. The contract was awarded in December 1936, and construction operations began early in 1937. It is expected that the project will be completed in 1938.

J. B. White is the project engineer for the United States Section of the International Boundary Commission in charge of this construction.

The intermittent flow of some of the boundary streams and the decrease in discharge caused by increased irrigation have given rise in the last few years to a number of sanitation problems—for example, the Tijuana River. This river, which discharges only at such times as there is heavy precipitation, crosses and recrosses the boundary in Lower California and empties into the Pacific Ocean about 3 miles below the San Diego Bay, flowing through the towns of Tijuana, Lower California, San Ysidro, Calif., and American farming communities. Sewage improperly treated has been discharged into the dry river, contaminating wells and menacing health.

In May 1935, the Boundary Commission reported to the respective governments the necessity for international cooperation on the construction of a single outfall sewer to the ocean. The project was approved by Mexico in November 1935, and it is expected that the United States will authorize and provide an appropriation for the construction of its portion.

VARIOUS TYPES OF SURVEYS MADE

The surveys now being made by the International Boundary Commission may be classed as boundary surveys, investigational surveys, and surveys of construction projects. The metric system of measurement is used for all surveys except those for construction projects within the United States which tie into existing systems already established in English units of measurement. In these cases, the English system of measurement is retained for convenience.

The first survey of the international boundary was made in 1852–1855 and is known as the Emory Survey, having been brought to successful completion under the direction of Maj. William H. Emory. This survey was made in accordance with the provisions of the Treaty of 1848, as modified by the Treaty of 1853. The difficulties encountered were many, but nevertheless the line was run in accordance with the best scientific and geodetic principles known at the time. The astronomical, meteorological, and hydrometric observations made, had they been published, would have filled a volume as large as that published annually by the Royal Observatory at Greenwich. In addition, much valuable scientific information was obtained regarding the inhabitants, the flora, fauna, geology, and meteorological conditions of the country traversed.

Fifty-two dressed stone monuments, generally laid without mortar, were established at rather infrequent intervals, and at points where trails or streams crossed the boundary line, piles of loose stone were erected. During the course of years, there arose an increasing demand for a closer monumentation of the land boundary line between El Paso and the Pacific. This was finally accomplished during the years 1891–1896. Many of the original monuments were found, and were replaced by monuments of more permanent construction. A large number of additional monuments were erected—in all, 258. In general, the monuments are intervisible, and the greatest distance between any two of them is now only about $4\frac{1}{2}$ miles.

JUAREZ AND EL PASO ON THE RIO GRANDE
Looking Upstream, Showing Cut No. 1 in the Foreground

RIVER BOUNDARY SURVEYS

During the period prior to 1900, the river boundary between the two nations also gave rise to many difficulties. Land which had been in the United States and settled upon by American citizens, overnight was cut to the Mexican side of the river. Similarly, Mexican citizens suddenly found their land to be on the United States side of the river. Such detached tracts are called "bancos." After several years of negotiation, the existing Treaty of 1905 regarding the elimination of bancos was concluded. This provides that where a banco is cut from either nation to the other by an avulsive river change, the sovereignty of the land changes to that of the country to which

it is cut except in those cases where the area exceeds 250 hectares, or the population exceeds 200 persons.

Precise base lines were run in the El Paso-Juarez Valley and in the Lower Rio Grande Valley between Roma and the Gulf of Mexico. After a river-boundary control had been established, elaborate topographic maps were made in order to study the various river movements that had occurred in the past and to decide which movements were erosions and which were avulsions. To date there have been 136 bancos eliminated in the Lower Rio Grande Valley, 14 in the Presidio Valley, 20 in the El Paso-Juarez Valley, and 2 along the Colorado River. In 1926 the Boundary Commission established its own triangulation system in the El Paso-Juarez Valley, which has lately been tied into by secondary triangulation of the Coast and Geodetic Survey. Boundary-survey work, as such, is now confined to the survey of bancos or to the establishment of additional intermediate monuments on the land boundary.

Investigational surveys are made for several purposes, such as the investigation of international reservoir sites, and preliminary determinations of the propriety and feasibility and cost of proposed engineering projects of an international nature.

Surveys for construction projects include property surveys made for acquiring rights of way, plane-table surveys for topographic maps, the running of location and profile lines, and the taking of cross-sections. Aerial surveys have proved themselves of invaluable assistance for all the varied work of the Commission. In an aerial picture, former or abandoned river beds show clearly, even in cultivated areas, and much time and effort which would otherwise have to be spent on reconnaissance, preliminary surveys, and map construction are saved.

HYDROGRAPHIC WORK ON THE RIO GRANDE

The hydrographic work of the Commission has as its primary objective the determination of the quantity and source of the flow of the Rio Grande at all pertinent points along the 1,500 miles of river from the Gulf of Mexico to the upper end of Elephant Butte Reservoir at San Marcial, N.Mex. A correlated objective is to ascertain from the records the extreme flows, median flows, and normal flows of the river and its tributaries at pertinent points. Other objectives are the determination by systematic water analyses of the suitability of the river flow for irrigation at various points and times, also its suitability for municipal and industrial use.

Because of the hydrographic and flood-control work on the Rio Grande it has become necessary, in times of large floods, to issue to the various river communities and to our own forces, flood warnings and flood forecasts. To eradicate a fruitful field of misunderstanding, the two sections of the Commission found it advisable in 1931 to undertake jointly the collection of water records, using unified methods and equipment.

Those hydrographic and related data covering the international features of the Rio Grande are published each year, and generalizations of data and authenticated and corrected records of former years are published as they become available. Each section of the Commission publishes the same data in its own language in the form of water bulletins.

Since 1931 the United States Section of the Commission has operated 16 gaging stations on the Rio Grande at pertinent points along the 1,500 miles of river between the Gulf of Mexico and San Marcial, N.Mex., and 14 gaging stations on United States tributaries near their confluence with the main stream. The Mexican Section has two stations on the Rio Grande and six on Mexican tributaries. During flood time several other stations are maintained.

COMPLETED CUTS NOS. 10 TO 13, WITH THE YSLETA-ZARAGOZA BRIDGE IN UPPER CENTER

The United States Section now samples for chemical analysis at seven points on the main river and at four tributaries. At various times and for various durations such sampling has been carried on at numerous points, especially on tributaries. Sampling for silt is carried on regularly by this section of the Commission at three points on the main river. The Mexican Section samples for silt on two tributaries and at one point on the main stream for water hardness and *B. Coli* count.

The accompanying map shows the locations of the various kinds of regular stations on the Rio Grande and its tributaries, and graphically portrays the scope of the Commission's hydrographic work. Engineer Karl F. Keeler is in charge of the hydrographic work of the United States Section of the Commission.

The efforts of the International Boundary Commission are "joint" in fact as well as in name, and the cooperative contributions of the Mexican Section in the development of combined plans have demonstrated their value. Engineering facts are, of course, the same in both languages. The engineering profession of Mexico has contributed some of its most able representatives to the Mexican Section.

ORGANIZATION OF THE COMMISSION

The International Boundary Commission is composed of a United States Section and a Mexican Section. Both sections are headed and staffed by engineers experienced in water engineering and with those problems peculiar to the Rio Grande and the Colorado River. The United States Section has headquarters at El Paso, Tex., and the Mexican Section at Juarez, Chihuahua, Mexico.

The following is the designated organization of the Departments and Commission: For the United States, Cordell Hull, Secretary of State; Lawrence M. Lawson, M. Am. Soc. C.E., commissioner (boundary and water); Culver M. Ainsworth, consulting engineer; H. J. S. Devries, acting secretary and counsel; and M. B. Moore, assistant secretary and chief clerk.

For Mexico, Gen. Eduardo Hay, Secretary of Foreign Relations; J. Pedrero Cordova, boundary commissioner; Gustavo P. Serrano, water commissioner; Joaquín C. Bustamante, consulting engineer; José Hernández Ojeda, secretary; and H. G. De Partearroyo, assistant secretary and translator.

Resources of the State of Texas

Ample Water Supplies, Agricultural Products, Forests and Minerals Are Available

FOLLOWING a brief outline of the Texas Planning Board's activities, four papers on various natural resources were delivered on April 21, 1937, before the general session at the San Antonio Meeting of the Society. Abstracts of these addresses, presented here, include descriptions of the state's water resources, agricultural products, forest reserves, and mineral wealth, respectively. Abstracts dealing with Texas industries appear elsewhere in this issue.

In the first article, Mr. Pritchett outlines the general situation with regard to water supplies and explains the reasons which led the Texas Legislature to adopt a policy of coordinated development of the entire watershed as a unit for each of the state's major streams. The leading agricultural enterprises of the state are next discussed by Mr. Buechel, who points out that the greatest need at present is for wider markets and greater industries—especially more processing plants.

Probably more timber grows each year in Texas under present conditions than is consumed, says Mr. Kurth, and if this balance should be maintained through proper utilization of existing stands and prevention or suppression of fires, the state's forest resources will be secured. In the fourth article, Mr. Sellards gives data on the location and extent of Texas' mineral deposits and mineral production, with special attention to oil, gas, lignite, iron, and potash. Some large deposits still await development.

Water Resources of Texas

By JOHN W. PRITCHETT

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BORDERED on the southeast by the Gulf of Mexico, the state of Texas has a coast line of about 375 miles. From this coast line the land surface rises towards the northwest where, in the high plains of the Panhandle, an elevation of 4,700 ft is reached. In the Trans-Pecos region of West Texas are mountainous regions with peaks reaching altitudes of more than one mile.

The coastal plain, ranging in elevation from sea level to slightly over 100 ft, has an average width of about 60 miles. From the coast to the Balcones Fault, there is a more or less gradual increase in elevation. This fault zone forms the southern and eastern boundary of the Edwards Plateau, with an abrupt increase in elevation of approximately 500 ft. Towards the northwest, the Edwards Plateau region rises more or less gradually until the breaks of the high plains, or Llano Estacado, are reached. Here there is another abrupt rise of about 500 ft. The Llano Estacado, extending northwesterly to the Texas boundary, has in general a very smooth surface, except for occasional stream channels or old abandoned channels. These outstanding topographic features have a marked influence on the water resources of the state.

The temperature of Texas is generally mild. The mean annual temperature ranges from about 74 F in the Lower Rio Grande Valley in the extreme southern part of Texas to about 54 F in the northwestern part of the Panhandle.

Precipitation in Texas is nearly all in the form of rain. Snow rarely reaches the southern part of the state and usually remains on the ground for only a few days. The mean annual rainfall for the entire state is about 25 in., yet a large area has insufficient moisture for dry land farming. Most of the state suffers from recurring droughts.

Relative humidity ranges from about 39 per cent in the extreme western part of the state to about 77 per cent along the coast. Annual evaporation, reduced to open

UPSTREAM VIEW OF BUCHANAN DAM ON THE LOWER COLORADO RIVER

water conditions, ranges from 41 in. to about 65 in.

The state constitution and laws governing public rights state that "the conservation and development of all the natural resources of the state, including the control, storing, preservation, and distribution of its flood and storm waters, the waters of its streams and rivers for irrigation, power, and all other purposes; the reclamation of its arid, semi-arid, and other lands needing irrigation; the reclamation and drainage of its overflowed lands and other lands needing drainage; the conservation and development of its forests, water, and hydroelectric power; the navigation of its inland and coastal waters and the preservation and conservation of all such natural resources . . . are . . . public rights and duties."

The statutes of the state, with reference to water rights, provide that "the waters of the ordinary flow and underflow and tides of every flowing river or natural stream, of all lakes, bays, or arms of the Gulf of Mexico, and the storm, flood or rain waters of every river or natural stream, canyon, ravine, depression or watershed, within the state of Texas, are . . . the property of the state . . . ."

The statutes further provide that preference and priority shall be given to the uses of public waters as follows:

1. Domestic and municipal.
2. Uses designed to convert materials from a lower order of value into forms having greater usability and value and to include water necessary for the development of power by means other than hydroelectric. (This is intended to cover uses for manufacture, but to exclude hydroelectric power.)
3. Irrigation.
4. Mining and recovery of minerals.
5. Hydroelectric power.
6. Navigation.
7. Recreation and pleasure.

Both the surface and ground-water supplies of the state are derived mainly from rainfall over its own area. The future growth and civic and industrial development of many of these areas are greatly dependent upon the water supply that may be economically developed.

The waters of the state have been an indispensable factor in the development of its vast oil resources. Not infrequently developments have had to await the procuring of a water supply. The control, conservation, and use of the waters of Texas is a matter that presents innumerable problems and enormous possibilities for development, and it is not within the scope of this paper to attempt to describe these numerous developed and proposed water conservation projects.

The state covers an estimated area of 265,890 sq miles, about 3,500 sq miles of which are water. Of the land area, about 30,000 sq miles in the western part of the high plains contribute little if any surface runoff to the streams. In any attempt at estimating runoff from rainfall and other climatological data, it is highly important to give proper consideration to this fact for such areas as are affected thereby.

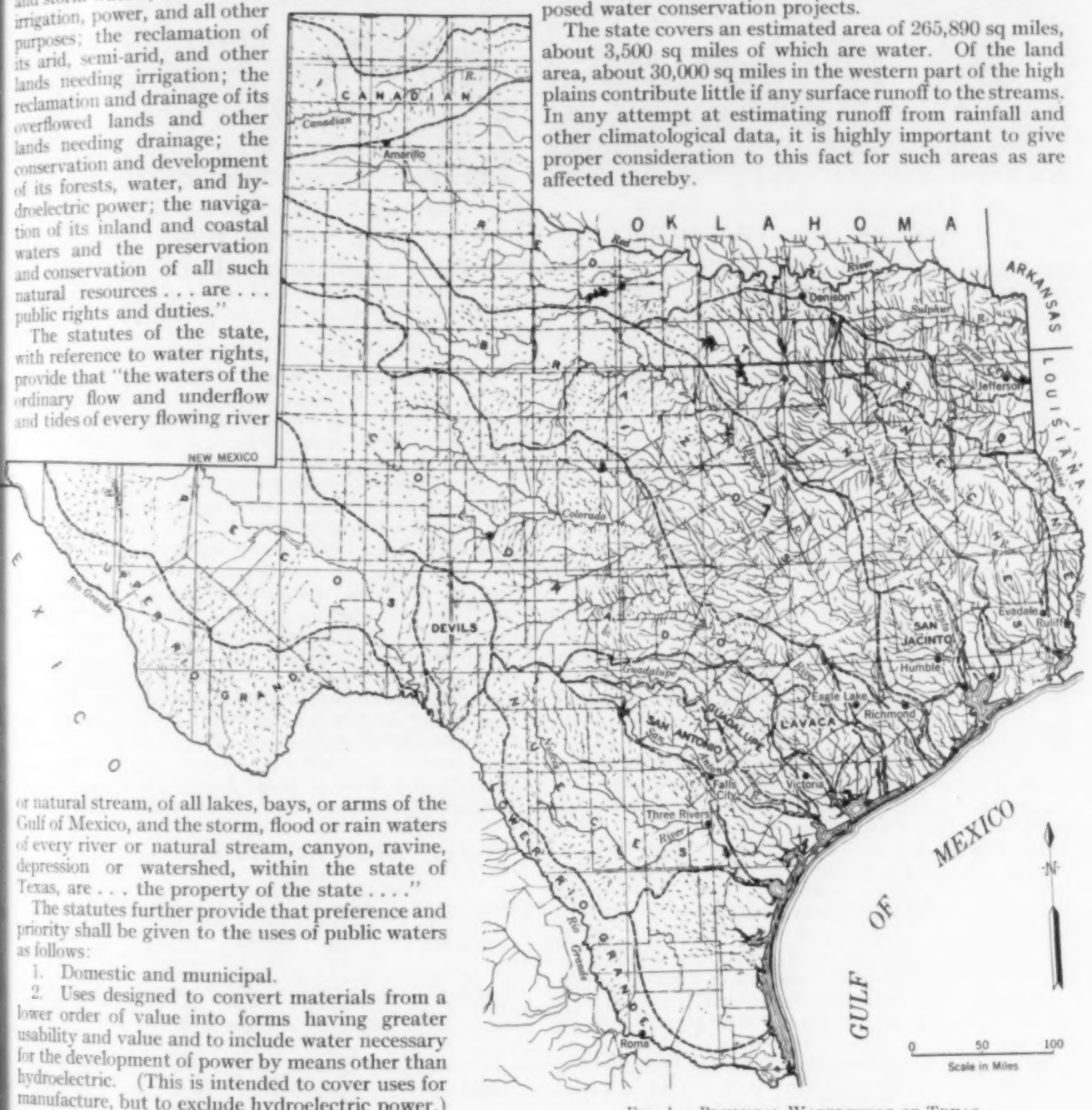


FIG. 1. PRINCIPAL WATERSHEDS OF TEXAS

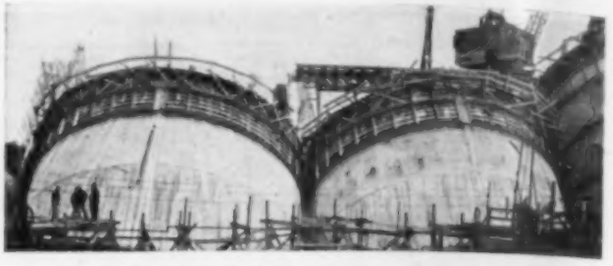
The runoff of Texas streams (shown in Fig. 1) at various gaging stations is given in Table I. It is estimated that the total runoff at the mouths of these streams is in the neighborhood of 42,980,000 acre-ft per year, or an average of 107 acre-ft per square mile of area.

CHARACTERISTICS OF SURFACE WATERS

The general direction of flow of most of the major streams is southeast; the main streams, throughout a greater part of their length, lie close to the northeastern

edge of the watershed; and the main tributaries come in from the southwest. Between the high plains and the coastal plains are numerous sites where surface waters may be advantageously stored for various uses. Not infrequently water may be economically stored for several purposes, at sites where it would not be found economical to store waters for any one particular purpose. In many instances storage for flood regulation may be economically combined with storage for other uses.

View of Tainter-Gate Section, Looking Downstream



Close-Up of 70-Ft Arch Sections, Inside Cofferdam

BUCHANAN DAM, FORMERLY HAMILTON DAM, IS BEING COMPLETED BY THE LOWER COLORADO RIVER AUTHORITY

The state has declared by statute its ownership to the public waters—the ownership of approximately thirty million acre-feet of water per year—of which about 2 per cent is now used for power and about 5 per cent for irrigation. To be of practical value, information concerning water resources must be correlated; must be worked out in accordance with a comprehensive plan; must be gathered over a term of years sufficient to warrant conclusions as to the storage, and to the maximum and the minimum quantities that may be expected; and must be of public record.

Gaging stations have been maintained on the principal streams of the state since 1914. Although records of this length are not sufficient to give an accurate idea of either the maximum or minimum flow to be expected, they are of great value when studied in their proper relation to other longer records, and with climatological data.

In Texas the use of rainfall data for estimating the runoff of streams by formula has frequently resulted in serious errors. Results obtained in this way are entirely too large. The flow of most of the streams is due to storm or flood flows. Percolation of water into the ground and finally into the streams is almost negligible for most of this area, and almost two-thirds of the rainfall is taken up by evaporation before it has an opportunity to reach the main streams, either as surface or seepage flow. The underestimating of maximum flood flows is quite common and there is urgent need for additional rain-gaging stations.

With the formation of the Brazos River Conservation and Reclamation District by the Texas Legislature in 1929, the state committed itself to the policy of the coordinated development of the entire water shed as a unit for each of its major streams. With reference to a legislative act diverting state taxes to the use of this district for flood protection, the Texas Supreme Court has said, "In every sense of the word the existence of this river uncontrolled is a continuing public calamity, to relieve which the state plainly has authority under the very constitutional provision invoked by the attorney general to grant public money for relief."

There are in Texas approximately 2,200 record appropriators of public waters. Almost no adjudication of these various rights has been accomplished. In order to properly administer the laws of the state with reference to the use of its public waters such adjudication is essential. The only legal method now for such adjudication is by individual action through the courts.

POWER DEVELOPMENT POSSIBILITIES

The Water Resources Branch of the U. S. Geological Survey estimates that Texas streams have a flow and gradient sufficient to develop one-half million horsepower during six months of the year. It is also estimated that the capacity of all generators now installed in Texas for the production of hydroelectric energy amounts to 32,310 kw.

The combined installations at the three dams now being constructed on the Colorado River and the Possum Kingdom Dam on the Brazos River will amount to 87,500 kw when the dams are completed, and provision is being made for additional installations of 65,000 kw. The proposed first installations for eight other major dams for the Brazos River Project amounts to 56,400 kw.

Summing up, it will be seen that in the near future the total installed capacity of hydroelectric generators in Texas will amount to 119,810 kw and that a possible total capacity of 221,210 kw may be anticipated when the Colorado and Brazos projects are completed. The total rated generator capacity in Texas for 1936 is estimated at 965,046 kw, or about nine times the present anticipated installation of hydroelectric plants and about 4.4 times

TABLE I. TOTAL RUNOFF OF TEXAS STREAMS

STREAM	DRAINAGE AREA	DRAINAGE AREA AT MOUTH	PERIOD RECORD	LENGTH RECORD, YEARS	ACRE FT. MEAN
Canadian River near Amarillo	20,000	[a]23,700	1924-25	1.71	437,000
Red River at Denison	33,570	[b]41,910	1924-35	11.98	3,744,000
Sulphur River near Darden	2,754	[c] 3,448	1924-36	13.00	1,327,000
Cypress Creek near Jefferson	848	2,664	1924-36	12.21	397,900
Sabine River near Ruliff	9,448	9,868	1925-35	11.00	5,788,000
Neches River at Evadale	7,908	9,993	1904-06, 1924-35	14.50	4,671,000
Trinity River at Romayor	17,190	17,730	1924-35	11.41	5,064,000
San Jacinto River near Humble	1,811	2,888	1929-35	6.94	799,700
Brazos River at Richmond	34,810	35,400	1903-06, 1923-36	17.50	[d]5,405,000
Colorado River near Eagle Lake	29,040	29,730	1904-11, 1916-36	28.00	[e]2,478,000
Guadalupe River at Victoria	5,676	6,144	1903-07, 1916-36	21.75	1,104,000
San Antonio River near Falls City	2,067	4,252	1925-35	10.47	166,900
Nueces River at Three Rivers	15,600	16,950	1916-36	19.00	578,000
Rio Grande at Roma	[f]160,000	[f]175,100	1900-14, 1923-25, 1928-35	22.46	4,395,000
Total	340,700	379,800			36,360,000

NOTE:
[a] Drainage area above Texas-Oklahoma line
[b] Drainage area above Texas-Arkansas line
[c] Drainage area above Texas-Louisiana line
[d] Records for Brazos River at Rosenberg used for 1923-1931
[e] Records for Colorado River at Columbus used prior to Oct. 1, 1930
[f] Published by International Boundary Commission in *Water Bulletin No. 4*

the anticipated total when the proposed Colorado and Brazos projects are completed.

Due to the vast reservoirs of oil and gas and the enormous beds of lignite coal in Texas, it is possible to produce electrical energy at a low cost. These natural resources of one kind or another are well distributed over almost the entire area of the state. As regards hydroelectric energy, however, it will be necessary to store flood waters on most of the streams of Texas in order to provide sufficient flow, and only where this water can be stored in combination with other uses, is its use for the generation of hydroelectric energy economically feasible.

For several of the proposed major reservoirs, the revenues to be derived from the sale of hydroelectric energy will materially assist in taking care of construction and maintenance costs, and a combination of uses is feasible. For use in combination with steam plants, the sale of hydroelectric energy should be a profitable source of revenue to the several watershed districts. The operation, at capacity, of constantly working steam plants, having standby storage reservoirs with power as a by-product to take care of peak loads, should produce energy at the lowest cost possible under conditions in Texas.

In what is known as the Lower Rio Grande Valley, comprising the greater parts of Cameron, Hidalgo, and Willacy counties, there are now about 750,000 acres of land under the several irrigation projects, of which about 400,000 acres are now being irrigated. This is one of the most important citrus-fruit-growing regions in the United States. Irrigation is necessary for the production of most crops, as the mean annual rainfall is about 25 in. There is an all-year-round growing season, and frost seldom occurs.

International agreement for the uses of, and plans for the development of the water resources of the Rio Grande are among the most important conservation problems of this state. There is now no agreement between the United States and Mexico as to the division of, or plans for, the conservation of the waters of this stream. Good storage sites are available along the Rio Grande, where large volumes of flood water could be stored and released as needed.

Some twelve years ago, the International Boundary Commission, representing the two governments, began making surveys, gathering data, and formulating reports to the end that such a treaty might be consummated and the conservation of flood waters might be undertaken. Upon the agreement of the United States that the distribution of the waters of the Colorado River be considered in connection with the distribution of the waters of the Rio Grande, a joint water commission representing the two countries was appointed for the purpose of making studies and collecting the necessary data upon which a treaty could be based. The duties of this water commission were later turned over to the International Boundary Commission, which is now administering them.

The state of Texas, through its governor and interested persons along the Rio Grande, has requested the Secretary of State, Cordell Hull, to negotiate a treaty between the two nations, for the equitable distribution of the waters of the Rio Grande. Pending the consummation of such a treaty with Mexico, nothing can be done to relieve the serious situation now confronting the irrigation interests of the Lower Rio Grande Valley.

MANY IMPORTANT SPRINGS

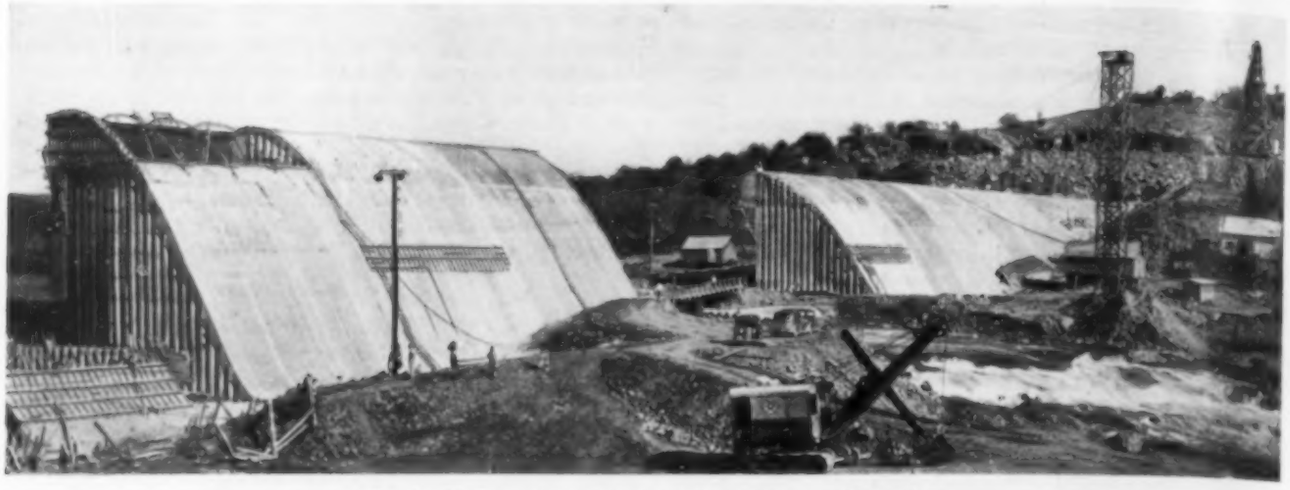
Some sections of Texas are noted for large perennial springs, the most important of which occur along the Balcones escarpment between the cities of Austin and Del Rio. The largest of this group of springs include Barton Springs, the San Marcos River, Comal River, San Antonio, and San Pedro springs in San Antonio, and Los Moras Springs, and San Felipe Springs. Pecan Springs on the Devils River and Seven Hundred Springs at the headwaters of the South Llano River are among the largest to be found in the canyons and valleys of the Edwards Plateau region. Many smaller springs in this area, from the Concho River southeastward to the Balcones escarpment, contribute considerable volume to the flow of the various rivers and tributaries that have their source in this region. Important among the springs of the area are those in the Nueces River watershed. In what is known as the Trans-Pecos region the most important springs are Comanche Springs and San Soloman Springs near Balmorhea.

Since the runoff of Texas streams is erratic, the amount of silt carried by them is also variable. Hence, the silt data become increasingly valuable with the length of the record secured, as averages calculated from them are safer for use in estimating the economic life of reservoirs as affected by the deposit of silt. Several records of nine years or longer have already been secured in the Brazos and Nueces watersheds, with numerous shorter records in other principal watersheds.

The results of the first of these cooperative silt investigations may be found in Technical Bulletin No. 382, "The Silt Load of Texas Streams," published by the U. S. Department of Agriculture.

Ground water, in the long run, will prove to be the most valuable underground resource of Texas. Numerous large cities and towns depend entirely on ground water for public and industrial water supplies. In many parts of the state irrigation from wells is already contributing substantially to the agricultural wealth. The need for adequate information regarding the factors that govern the quantity and quality of the available supplies has been brought out in a striking manner by the droughts in recent years. Wells failed in large numbers

DOWNSTREAM VIEW OF BUCHANAN DAM



SPILLWAY SECTION OF ROY INKS DAM, LOOKING UPSTREAM
This Relatively Small Structure Is a Few Miles Below Buchanan Dam

in different parts of Texas, even in the eastern and northeastern parts of the state where the annual rainfall usually amounts to from 45 to 55 in. In several areas where the ground-water resources have been extensively developed, the main problem is the determination of the amount of water that may safely be withdrawn each year.

The search for ground-water supplies in undeveloped areas has scarcely been started, but it is indicated that large supplies are available in several new areas. The outstanding conclusion is that in order to get the full benefits of the great underground water supplies in Texas, the development of these resources must be intelligently guided. Waste should be stopped, and exploitation of the underground water supplies beyond safe limits should be checked before it is too late.

While it is true that the supply of water in most instances has been sufficient to meet present needs, some sections have already faced a shortage and future developments of many sections depend upon careful conservation. There is need for more detailed study of the water resources, for more stream-flow gaging stations and more precipitation stations.

Due to enormous flood damages, it is urgent that construction of large storage reservoirs be undertaken as soon as the projects already studied can be financed. The immediate need is for further studies of flood control and conservation of the surface water and ground-water resources.

A grave situation exists in regard to the division of the water of the Rio Grande between the United States and Mexico, and it is most important that a treaty on this subject be negotiated as soon as possible.

Agricultural Resources of Texas

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TEXAS is the largest state in the Union, and its area is equal to the total area of the leading "corn-belt" states—Iowa, Illinois, Nebraska, Indiana, and Ohio, all large states. Far more important, however, than mere area is the wide physical diversity of the state, which has an important bearing on the variety, volume, and quality of its agricultural resources.

Among the studies that have been made of the state is one by Elmer H. Johnson, of the Bureau of Business Research, the University of Texas, which deserves special emphasis. In the resulting monograph, entitled "The Natural Regions of Texas," Mr. Johnson has integrated into a new concept the work of the great soils scientist, C. F. Marbut; that of the great authority on short grasses, H. L. Shantz; and that of the leading Texas geologist, Robert T. Hill—among many others. By means of this sort of analysis, the appropiate use of land, whether for grazing forests, or crops, is made relatively obvious, and the basis for zoning becomes an actual scientific fact.

Hitherto, the delineation of the natural agricultural regions of Texas and the nation has been accomplished by the actual settlement of individual farmers, who through the process of trial and error have adjusted themselves to their environment. So successfully has this been done that the broad outlines of land use within the state and in the country at large have attained a stability which will probably change but slowly in the future, such changes being minor adjustments resulting from local variations in soil, climate, topography, and markets. It is to be hoped that science and technology may be brought more consciously into play in the future, so that the adjustments yet to be made may occasion less loss to the individual and to the state.

In the state of Texas, environmental advantages for the production of certain crops or livestock are so pronounced, and transportation from farm to market is so improved that the tendency for a given region to specialize may be expected to increase rather than to diminish. The foregoing statement applies only to the main enterprises of the farm or ranch, and is not intended to minimize the desirability of diversification as represented by well-kept gardens, a flock of chickens, a few hogs, and a few dairy cows or more where economically feasible.

The U. S. Department of Agriculture Crop Reporting Service has revised its crop-reporting districts for Texas

so that they now conform to the relatively homogeneous areas delineated in the "The Natural Regions of Texas." Eleven districts, each possessing distinct characteristics, are used. The number of each district, together with the cash income from crops, livestock, and livestock products in 1929 for each, appear in Fig. 1.

In this connection it should be noted that in the two census years, 1925 and 1929, there was but little change in the acreage of harvested crops in districts 3, 4, 5, 6, 7, 8, and 9, whereas there was a substantial increase in the case of districts 1-N, 1-S, 2, and 10. This reflects the agricultural expansion in the latter four areas during the five-year interval.

In the period 1929–1934 there were further substantial increases in crop acreages in districts 1-N, 1-S, and 2. What the 1939 census will show regarding these three areas is a matter for interesting conjecture in view of the current public interest in land utilization and government activity. The engineer is also particularly interested in these districts of West Texas because the interrelated problems of erosion control, water conservation, and flood control center about this area.

According to the United States Census, about 55 per cent of the acreage harvested in Texas during 1929 was devoted to cotton. The remaining acreage was distributed as follows: Corn, 13.9 per cent; sorghum, 12.0 per cent; wheat, 9.7 per cent; oats, 4.3 per cent; all other crops, 5.2 per cent.

Since the percentage of total land in harvested crops for each district (Table I) differs so widely, the percentage of land in selected crops (Fig. 2) should always be considered in conjunction with it. For example, in District 6 with less than one per cent, or 127,000 acres, in harvested crops, 73 per cent of the harvested acreage is devoted to cotton; whereas, in District 4 with 60.5 per cent, or 7,152,000 acres, in crops, 62.7 per cent, a considerably smaller percentage, is planted in cotton. Yet the actual acreage in District 6 is almost negligible in comparison with District 4. A number of other districts have quite distinctive crop characteristics. It will be noted that wheat predominates in the northern half of the Panhandle and cotton in the southern.

Agricultural income in Texas is derived from a wide range of products, but the bulk of it comes from a comparatively small group. In 1929, for the state as a whole, about 56 per cent of the total farm cash income was derived from cotton and cottonseed, about 30 per cent from livestock and livestock products (including poultry and eggs), and nearly 6 per cent from wheat and rice. Thus about 92 per cent of the cash income of the state is derived from three groups of products.

Each of these groups includes products grown under highly specialized conditions—notably, cotton, wool, mohair, wheat, and rice. Relatively little or none is accordingly retained for home processing or consumption, the output passing almost entirely through the channels of trade, subject to national and international market conditions. Any policy or program respecting these commodities is, therefore, reflected immediately in farm cash income and thus influences the agricultural resources of the state.

During the past nine years there has been a wide variation in the annual farm cash income in Texas. This income has been computed for the state, and it is believed that error, in the form of an understatement, does not exceed 10 per cent. In Fig. 3 the annual farm cash income is shown for the nine years 1927–1935, broken down into the five groups of cotton and cottonseed, grains, livestock, and livestock products, all other products, and rental and benefit payments. During the past four years, farmers have been receiving additional income from the federal government in the form of rental

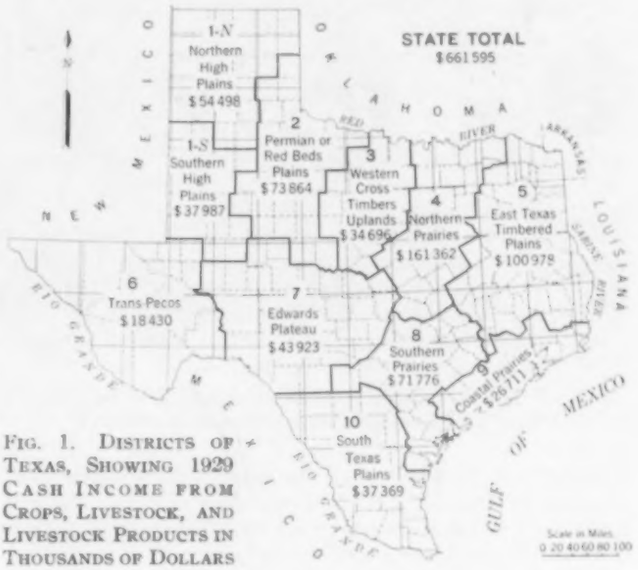

FIG. 1. DISTRICTS OF TEXAS, SHOWING 1929 CASH INCOME FROM CROPS, LIVESTOCK, AND LIVESTOCK PRODUCTS IN THOUSANDS OF DOLLARS

or benefit payments in return for cooperation in the crop-restriction program. It will be noted that the computed annual cash income for the entire state varied from nearly $800,000,000 in 1928 to less than $300,000,000 in 1932.

AGRICULTURAL SPECIALIZATION AND POPULATION DISTRIBUTION

Illustration of the added significance which the agricultural statistics of Texas attain when the data are assembled in conjunction with logical geographical divisions is to be found in Table I, previously mentioned. Attention is directed especially to the last three columns of this table.

In the two adjacent districts constituting the Texas Panhandle (1-N and 1-S), for example, some significant differences will be noted. Although the percentage of farm land devoted to crops in these adjacent areas is almost the same, in District 1-N there are 197 acres of farm land per rural person with 60 acres in harvested crops; whereas in District 1-S there are 88 acres per rural person with 29 acres in harvested crops, less than one-half as much as in District 1-N. Why this difference? The superficial answer is, of course, that wheat is grown

TABLE I. DISTRIBUTION OF RURAL POPULATION IN TEXAS FOR 1929, BY DISTRICTS

From the Report of the U. S. Bureau of the Census

District Number	Total Population	Rural Farm Population	Per Cent of Rural Population to Total	Total Acres (in Thousands)	Total Harvested Acreage (in Thousands)	Per Cent of Harvested Acreage to Total	No. Acres per Rural Person	Harvested Acres per Rural Person
1-N	197,928	61,284	31.0	12,091	3,689	30.5	197	60
1-S	161,594	84,963	52.6	7,504	2,426	32.3	88	29
2	441,198	204,970	46.5	13,563	4,604	33.9	66	22
3	287,228	136,870	47.7	8,832	1,830	20.7	65	13
4	1,441,743	541,730	37.6	11,827	7,152	60.5	22	13
5	969,227	634,725	65.5	10,534	4,452	42.3	17	7
6	189,767	21,885	11.5	16,103	127	0.8	736	6
7	203,350	83,612	41.1	19,830	1,068	5.4	237	13
8	870,777	339,030	38.9	10,545	3,427	32.5	31	10
9	734,391	118,119	16.1	4,388	860	19.6	37	7
10	327,512	115,365	35.2	9,495	999	10.5	82	9
State	5,824,715	2,342,553	40.2	124,712	30,634	24.6	53	13

in 1-N and cotton in 1-S. But why is there such a high degree of specialization in wheat in this area (more than 80 per cent of the wheat of the state) and of cotton in District 1-S? As a further indication of important differences in the two districts, it will be noted that in

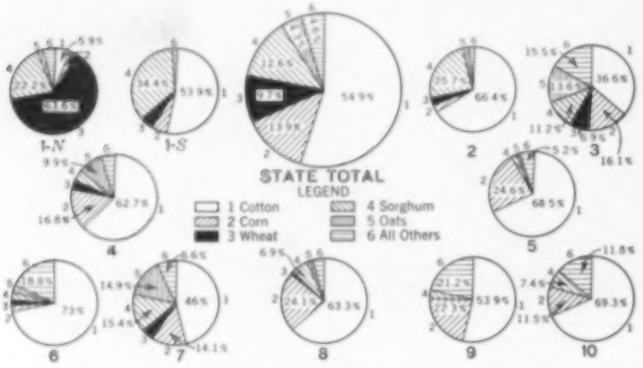

FIG. 2. PERCENTAGE OF HARVESTED ACREAGE IN SELECTED CROPS BY DISTRICTS AND FOR TEXAS AS A WHOLE

District 1-N, 31 per cent of the total population is rural, whereas in District 1-S, 52.6 per cent is rural. Wheat lends itself to more extensive agricultural operations than does cotton, and hence not so many people are required. Of interest, too, is the fact that in 1929 the per capita farm cash income in District 1-N was $889, and in District 1-S $447.

Although Districts 3 and 4 are adjacent, they also present some interesting contrasts. The rural population represents 47.7 per cent of the total in District 3, and 37.6 per cent in District 4; harvested acreage represents 21 per cent of the total in District 3 and 61 per cent in District 4. There were 65 acres of land per capita in District 3 and 22 acres in District 4, while the per capita farm cash income in 1929 was $250 in District 3 and $300 in District 4.

One more example of this type may be cited, but similar comparisons are given for all districts in the table and charts. In District 6 less than 12 per cent of the population is rural, while in the contiguous region to the east, District 7, the percentage is 41.1. Less than one per cent of the land in District 6 was in harvested crops in 1929, whereas in District 7 there was 5.4 per cent. In District 6 there were 736 acres of land per person, while in District 7 there were only 237 acres. Per capita cash income in District 6 was $841, and in District 7 it was $527. These two districts in West Texas may be compared with District 5 in East Texas, in which the farm population constituted 65.5 per cent of the total, and the acreage in harvested crops was 42.3 per cent of the land in farms. There were 17 acres of land per rural person, and the per capita farm cash income was less than $160.

The foregoing is perhaps sufficient to show the wide differences that exist in rural conditions in the different parts of Texas. Incidentally, the significance of the scientific geographical delineations of the state for statistical purposes is clearly illustrated. Averages used in conjunction with the relatively homogeneous crop-reporting districts mean much more than averages applied to the state as a whole.

Although agriculture provides employment for more workers than any other one industry in Texas, its relative importance in this respect has been declining ever since 1900. In that year 644,634 persons were gainfully employed in agriculture. This was 61.8 per cent of the total number gainfully employed in the state. In 1910 the number of agricultural workers had reached 934,140, but this represented only 60 per cent of the total number of workers. In 1920, agricultural workers numbered 793,840, or 46.2 per cent; and in 1930, they numbered 841,347, or 38.1 per cent of the total workers. Since 1930, as a result of the government's program of restricting cotton acreage, in addition to the normal trend, there has been little doubt that at least the percentage decline in the number of rural workers has continued, and it is entirely possible that there has been a decrease in actual numbers.

A similar downward trend in the ratio of agricultural workers to total workers noted in Texas also occurred in the country at large, but at a date considerably earlier. In 1890 rural workers in the United States constituted 36.7 per cent of the total gainfully employed. By 1900 the percentage had dropped to 35.7 per cent; while in 1910 it was 33.2, in 1920 it was 25.6, and in 1930 it was down to 21.4 per cent. The year 1910 showed the greatest actual number of gainful agricultural workers in the history of the country.

MARKETS, INDUSTRY, AND PROCESSING PLANTS

The greatest need for promoting further expansion of the agricultural resources of Texas is for wider markets for the agricultural raw materials of the state; and in addition, for industries of all kinds, especially agricultural processing plants, for providing nearby markets. During the past few years a serious loss has been sustained as a result of the decline in foreign demand for Texas cotton. This was reflected in the recent report on farm cash income by the U. S. Bureau of Agricultural Economics, which indicates that in 1936 Texas stood fourth among the states, whereas usually it has been first.

Loss of markets, together with the low price of cotton, reduces the current agricultural income of the state and also diminishes the value of farm property, which, in the last analysis, is derived from income. This loss of asset value is probably even more serious than that of current income.

Plants for processing farm products are increasing in number and size. Citrus-canning plants are being built in the Lower Rio Grande Valley. There has also been considerable development of vegetable canning in that valley and in East and North Central Texas. Dairy

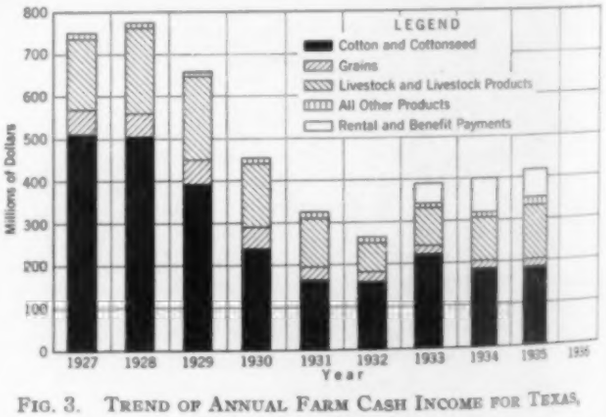

FIG. 3. TREND OF ANNUAL FARM CASH INCOME FOR TEXAS, 1927–1935, BY PRODUCTS

manufacturing plants have increased steadily during the past ten years, both in number and size. For example, in 1928 less than one million pounds of cheese was made in Texas, while in 1935 there was an output of more than 10 million pounds, and in 1936 production probably ex-

ceeded 12 million pounds. There has also been an expansion in the number and output of garment factories, and the upward trend appears to continue.

With more than a million head of livestock of all classes being shipped out of the state annually, there should be wide scope for further expansion in the meat-packing industry. Egg-processing plants offer good possibilities in Texas, and poultry-processing has been mentioned as a possibility. Progress in the cotton textile industry has not been as rapid as it might have been, and there are at present no plants for even the simplest processing of wool and mohair.

Human wants provided the incentive; science, skill, and technology, the instruments; and natural environment, the physical bases upon which man and his organizations operate. Statistics are significant in showing the trend of agricultural resources, but the actual resources are the human factors—intelligence, character, resourcefulness—acting on their physical environment through their social and economic institutions.

Since no single factor is as important for the development of the agricultural resources of the state as a leadership which thoroughly understands the forces with which it is dealing, an effective program for increasing the agricultural resources of Texas involves the following factors:

1. Analyzing, interpreting, and delineating the natural regions of the state.
2. Securing remunerative outlets for the surplus production.
3. Development of industries immediately dependent upon agricultural raw materials, such as fruit and vegetable-canning; meat-packing; flour- and feed-milling; spinning and weaving cotton, wool, and mohair; and the production of butter, cheese, concentrated milk, and ice cream.
4. A system of public school and college education giving thorough training in fundamental subjects and kept vital with materials growing out of the agricultural, economic, and social life of the state.
5. Graduate courses in the institutions of higher learning designed to equip young men and women with a knowledge of the fundamentals of the physical and biological sciences, and the underlying environmental forces of Texas, the Gulf Southwest, and the country as a whole.

Forest Resources of Texas

By E. L. KURTH

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FOREST resources are unlike most other natural resources in that forests renew themselves, if ample seed trees are left and the area is protected from forest fire. In view of this condition, trees in southern forests should be thought of as a crop rather than as a natural resource. The virgin forests of the South, as they existed when found by the white man, were considered a natural resource because they came with the country. Today, however, only a comparatively small part of this area remains; instead, there is a vast area of second, third, and sometimes fourth growth. Periodic harvesting of the timber has created the crop, and from this crop comes the continuity of the timber industry, not only in Texas but throughout the South and the nation.

Of the 167,935,000 acres comprising the land area of Texas, approximately 35,000,000 are covered with forest growth. According to the best statistics available, these forest resources included 12,624,000 acres of commercial pine and hardwood in East Texas; 5,000,000 acres of east and west cross timbers; 10,000,000 acres of post oak; 3,000,000 acres of cedar brakes; and 3,000,000 acres of mesquite.

Of this forested area, about $22^1/_2$ million acres are classed as protection forests, because generally speaking they serve their highest purpose by assisting in the control of water runoff and greatly reducing if not entirely preventing, erosion. They may, at the same time, yield products more or less useful to man. The area of protection forests is made up chiefly of the cedar brake, east and west cross-timber, post-oak, and mesquite regions.

The $12^1/_2$ million acres remaining constitute the commercial pine and hardwood region of East Texas. Originally, this region supported about $18^1/_2$ million acres, but the better soils, as well as many of the poorer ones, were taken over by agriculture.

The commercial pine area includes 80,000 acres of virgin timber; 2,260,000 acres of second growth (8 in. in diameter breast high and up); 3,620,000 acres of second growth (less than 8 in. d.b.h.); 3,605,000 acres of fair to good reproduction; and 1,050,000 acres of cut-over (poor reproduction)—a total of 10,615,000 acres.

The hardwood area includes 150,000 acres of virgin timber; 360,000 acres of second growth (8 in. d.b.h. and up); 530,000 acres of second growth (less than 8 in. d.b.h.); 605,000 acres of fair to good reproduction; and 364,000 acres of cut-over (poor reproduction)—a total of 2,009,000 acres.

The 1,050,000 acres of commercial pine referred to as having poor reproduction are located largely in the long-leaf pine region where the original virgin timber stand was practically 100 per cent merchantable and over-mature. However, this area is beginning to show some signs of recovery. The timber lands of East Texas are not owned entirely by large companies. As a matter of fact, according to the 1935 agricultural census, the farmers own 4,426,000 acres, or over 35 per cent of the 12,624,000 acres of pine and hardwood in East Texas. The farmers owning timber land therefore constitute a very important group in connection with the production of future timber supplies.

TEXAS TIMBER AND PAPER PULP

A survey by the Southern Forest Experiment Station of the U. S. Forest Service, covering 17 counties in southeastern Texas with a net forested area of 6,599,500 acres, was completed in August 1935. This survey shows the average wood volume per acre, for all species 6 in. in diameter $4^1/_2$ ft from the ground and larger, to be 12.64 cords. Of this total volume per acre, only 6.89 cords of pine and 2.02 cords of pulping hardwoods, or a total of 9 cords per acre, can be utilized in the manufacture of paper pulp.

If these figures are taken as representative of East Texas and are applied to the entire 12,624,000 forested acres, the East Texas commercial timber belt is found

capable of yielding approximately 113,616,000 cords of wood suitable for pulp manufacture. But it must be clearly understood that this total amount of cordwood will not be available for pulp production, since part must be allocated to numerous other wood-using industries.

A pulp mill having a daily capacity of 100 tons of pulp will use each year about 60,000 cords of wood. The survey report indicates that there are approximately 30 million cords of trees ranging from 6 to 10 in. (not considered large enough for saw timber). This means that the 30 million cords that are available today would be enough to supply 25 pulp mills having a daily capacity of 100 tons or 200 cords, 365 operating days per year, for a period of 16 years.

The pulp mills that are operating at present are consuming pine timber only. On the basis of our present information, it is estimated that growth in the East Texas timber belt is approximately one-half cord per acre per year throughout the area. With wider application of advanced logging methods and elimination of forest fires, this rate could no doubt be doubled. Under the present conditions nature is adding about 5 million cords additional annually. The estimated saw-timber stand in Texas Survey Units Nos. 1 and 2, according to I. F. Eldredge, regional survey director, is 10,291,000,000 board ft for pine 9 in. d.b.h. and up; and is 7,444,000,000 board ft for hardwoods 13 in. d.b.h. and up, or a total of 17,735,600,000 board ft by the Doyle scale.

The southern yellow pine is probably the most important commercial species grown in Texas, having made a larger contribution to the annual production of timber products than any other species. Further attention should therefore be paid to its growth possibilities. Nature has endowed the pine regions of East Texas with long growing seasons, an average rainfall of 45 to 50 in., and a soil well adapted to timber growing. All these factors offer exceptional possibilities for sustained yield and the growing of timber as a crop.

Over a period of years, the Texas Forest Service has made growth studies in various parts of East Texas and made estimates of growth for the three most widely grown pines. From these studies it appears that the following conservative averages may be taken for the southern yellow pines of East Texas: For shortleaf pine, a volume increase of 4.6 per cent annually; for loblolly pine, 6.2 per cent annually; and for longleaf pine, 5.0 per cent annually, making a general average of 5.3 per cent annually.

As an example of the application of these figures, let us say a certain acre has a long-scale volume of 5,000 ft for all pine 10 in. in diameter and larger. The annual growth is then 265 ft per acre per year. By applying growth percentages to the volume estimate and using compound interest, any owner of timber land can determine what the approximate log-scale volume will be in 10 or 20 years, based on those trees considered in the original estimate. Of course such future estimates are not exact because of many natural factors, yet they can be used as a guide for the future. By the application of scientific forestry, guesswork can practically be taken out of timber growing.

In considering growth, it is interesting to compare the southern forest region, of which East Texas is a part, to that of other forest regions in the United States, and to note particularly the growth in the South as compared with growth in the New England and lake states regions, where the pulp industry is centered.

In United States Senate Document No. 12, prepared by the U. S. Forest Service, there is a table marked, "present current annual growth of usable material on commercial-forest areas of the United States by regions." This table shows the growth for the New England States to be 427 million cubic feet per year, and for the lake states 644 million cubic feet. But for the South we find a growth of 4,784 million cubic feet, or over four times as much as the combined growth of the New England and

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A TYPICAL FOREST OF VIRGIN LONGLEAF YELLOW PINE IN NEWTON COUNTY, EAST TEXAS

lake states. The total growth for the United States, which covers all the eight regions, is given as 8,912,000,000 cubic feet. Over half this amount is credited to the South.

Considerable space has been taken up in the discussion of the growth. But since the timber industry in Texas is aiming towards permanency, the growth rate of its raw material is a vital basic factor. Today there is probably more timber growing per year than is being consumed by the industries. By keeping this balance, the production of forest products in Texas need never cease, and the industries involved in the timber business will continue to be important factors in the industrial development of the state. Trees are nature's handiwork at its best. By proper utilization of timber and the prevention and suppression of forest fires, the timber of Texas can be grown as a crop and the benefits secured for our posterity.

Mineral Resources of Texas

By E. H. SELLARDS

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STATE and government agencies engaged in the development of the mineral resources of Texas include the State Planning Board, which has maintained a mineral resource committee since its establishment two years ago; and the U. S. Geological Survey, which has had parties working in Texas from time to time and has made a large contribution towards knowledge of our geology and mineral resources.

In the University of Texas there is a Division of Conservation and Development of Natural Resources of Texas, which includes the Bureau of Industrial Chemistry, Bureau of Engineering Research, and Bureau of Economic Geology, the last named being the bureau in which I myself am working. These bureaus have been engaged in this work for the past twenty-seven years, and are continuing it with such funds and opportunities as are provided by the state.

Among the mapping agencies are the U. S. Coast and Geodetic Survey, the State Board of Water Engineers, the State Reclamation Department, and other state organizations such as the Brazos River Conservation and Reclamation District, which is doing very important work in the region with which it is concerned. In addition, extensive investigation of mineral resources is being carried on by private agencies. The information thus obtained can best be given to the public through publication, and all the agencies mentioned publish their results for the benefit of the public.

TABLE I. MINERAL PRODUCTION IN TEXAS, BASED ON THE QUANTITY SOLD IN EACH CASE

Statistics Are for 1935 Production Unless Otherwise Noted

ITEM	QUANTITY	VALUE
Asphaltic limestone, tons	74,594	$ 241,442
Carbon black, pounds	275,000,000	11,000,000 (*b*)
Cement, barrels	3,715,300	6,422,807
Clay products	.....	1,500,000 (*c*)
Coal, tons	35,971 (*d*)	97,000
Copper, pounds	28,000	2,324 (*1*)
Fuller's earth, tons	40,925	391,641
Gold, troy ounces	518	18,130 (*2*)
Granite, tons	22,040	47,413
Gypsum, tons	179,783	1,812,605
Helium, cubic feet	10,218,480 (*e*)	114,216 (*e*)
Lead, pounds	1,043,000	41,720 (*3*)
Lignite, tons	721,558	557,000
Lime, tons	38,863	362,636
Limestone, tons	1,000,400	1,188,752
Mercury, flasks (76 lb)	4,000	288,000 (*f*)
Miscellaneous stone, tons	192,410	133,341
Miscellaneous	.....	164,345 (*a*)
Natural gas, M cubic feet	642,360,000	14,000,000 (*g*)
Natural gas-gasoline, gallons	504,160,000	16,838,944 (*h*)
Oil, barrels	391,097,000	371,664,170 (*4*)
Salt, tons	268,809	563,514
Sand and gravel, tons	4,895,362	2,839,513
Sandstone, tons	33,120	34,248
Silver, troy ounces	1,000,960	719,440 (*5*)
Sulfur, long tons	1,354,101	24,373,818 (*6*)
Total value, eliminating duplication		$455,417,019

(*a*) Includes basalt and natural sodium compounds
(*b*) Estimated
(*c*) Estimated. Raw clay produced in 1935 to the amount of 46,538 tons valued at $261,623 not included in the total for the state
(*d*) Includes cannel coal produced in Webb County
(*e*) Production is for the fiscal year, July 1934 to June 1935
(*f*) Estimated. Exact quantity not reported by operating companies
(*g*) Estimated. Includes only gas metered through pipe lines
(*h*) Value obtained by using average price for the United States, at plant, of 3.34 cents per gal
(*1*) Production for 1936, 52,000 lb, valued at $4,784
(*2*) Production for 1936, 675 troy oz, valued at $23,625
(*3*) Production for 1936, 1,045,000 lb, valued at $48,884
(*4*) Production for 1936, 426,897,000 bbl, valued at $400,000,000
(*5*) Production for 1936, 1,383,000 troy oz, valued at $1,064,910
(*6*) Production for 1936, 1,723,292 long tons, valued at $31,019,456

PRODUCTION TOTALS HALF BILLION ANNUALLY

The total value of minerals produced in Texas to date is $6,500,000,000, based on records extending back a little more than 50 years. The value of the annual mineral production approximates $500,000,000. There are 28 or more commodities included in this total. In Table I is a brief summary showing the production of minerals and mineral products in Texas for 1935. Information for 1936 is not yet fully assembled, although a partial statement of production in 1936 is available to those who are interested. In these statements the quantity given is the amount shipped. Value is based on sale price at the locality of production.

Leader in the mineral resources of Texas is the giant industry of petroleum. The production of oil in Texas during 1936 was close to one-half billion barrels. The number of wells drilled for oil and gas in the state during the year was about 12,500, or somewhat more than in all the other states of the Union combined. The oil reserves of the state are believed to be larger than those in any other part of the United States. Oil production is from geologic formations, ranging in age from very old, lower Ordovician, to late Tertiary. The number of distinct oil fields, which can be given only approximately, is about 400. Production of gas is amazingly large, but utilization lags behind production, and better utilization is one of the state's greatest needs.

The accompanying map (Fig. 1) shows the principal oil-producing regions. Certain producing areas will be mentioned in detail, as follows:

Reynosa escarpment—Production from sands, somewhat affected by faulting.
Mercedes or Rio Grande Valley—Production from sands.
Pettus—Production from sands in anticlines, affected by faulting.

Corpus Christi—Production from anticlines, affected by faulting.
San Antonio—Production from sands, accumulation controlled by faulting.
Luling—Production mostly from limestones; accumulation controlled by faulting. Some production from serpentine.
Coastal salt dome—Salt dome production.
Mexia fault zone—Sand production, controlled by faulting.
Tyler Basin—Sand production from domes.
East Texas—Sand production, controlled by stratigraphic conditions.
Bend arch—Sand and limestone production.
Nocona—Sand and some limestone production on Muenster arch.
Wichita—Sand production from domes on Electra arch.
Amarillo—Production from sand and limestone, controlled by stratigraphic conditions and domes on the buried Amarillo Mountains.
Southern High Plains—Production from sands and limestones.
Crane and Winkler—Production from sands and limestones, controlled by stratigraphic conditions and regional uplift.

Lignite constitutes an undeveloped resource, awaiting the inevitable time when the more desirable fuels, gas, and oil, have been used up. The principal belt of lignite is in northeastern Texas, but it extends throughout the Gulf Coastal Plain. A summary of information on coal and lignite has been given in a recent volume, *University of Texas Bulletin 3401*. In this reference the workable area of lignite in the state is estimated as only a little less than one-half the total estimated workable area of the United States. The mapping of lignite has not progressed as far as one could wish.

LARGE DEPOSITS OF IRON ORE

Attention is called particularly to the iron-ore deposits of Texas, which are located principally in the northeastern part of the state. Recently the origin of the deposits has been worked out with considerable care. The parent mineral is glauconite or iron silicate, and several formations in the Tertiary belt in northeast Texas contain this mineral. It is, however, most abundant in the Weches formation, a member of the Claiborne group of the Eocene. At and near the surface this mineral, glauconite, disintegrates and is altered to limonite.

Lack of understanding of this method of origin of the iron ore has led in the past to some overestimates as to the quantity. If, for instance, the ore is exposed around the sides of a hill, it would naturally be assumed that the stratum passed under and through the hill, but our present knowledge leads us to believe that it does not continue any great distance underground—only as far, in fact, as the abundant mineral, glauconite, has been affected by oxidation. After a careful study, Eckel and Purcell estimated (*University of Texas Bulletin 3401*) that the reserves of commerical ore in this region are in the neighborhood of 200,000,000 tons, exclusive of the large quantity of low-grade ore that may or may not be used in the future.

Among Texas mineral products, I want to call attention to the glass-making possibilities. Of great importance in this industry is the cheap fuel so readily available in the form of gas. Much less sand is produced in Texas and used there for glass manufacture than is shipped from the state to be used in Mexico or elsewhere. Why should this sand be shipped away from the region where fuel is the cheapest and the most abundant?

For the past few years the Bureau of Economic Geology and the Bureau of Engineering Research of the University of Texas have been giving special attention to building stone. Examinations of promising stone have been made at the places of occurrence, samples suitable for testing have been collected, and laboratory tests are now being carried on. The stones being tested are chiefly limestones, marbles, and granites.

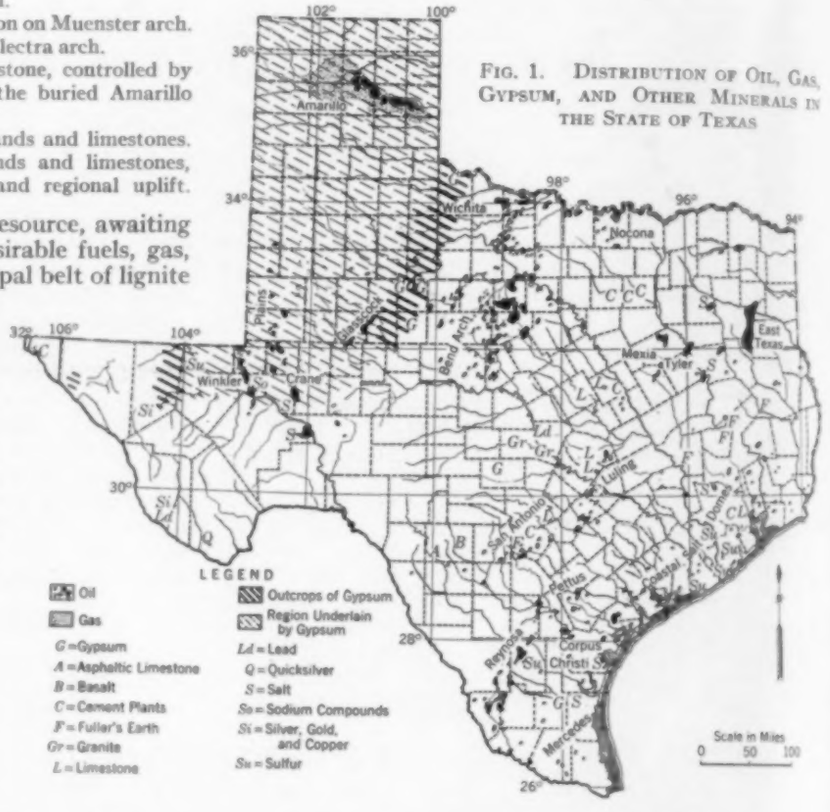

FIG. 1. DISTRIBUTION OF OIL, GAS, GYPSUM, AND OTHER MINERALS IN THE STATE OF TEXAS

POTASH RESOURCES AS YET UNDEVELOPED

There are other resources which require further exploration to be brought into commercial production. One of these is potash. Considerable exploration for potash has been carried on. Two mines have been put into operation in New Mexico near Carlsbad, and it is reported that a shaft is being started for a third mine. The potash mineral produced in New Mexico is sylvite. In Texas, explorations have not extended to the point of starting mining operations, but the region of possible location of potash is very large, extending from the Pecos Valley northward to Amarillo.

There is a considerable annual output of some very common minerals. The recorded annual value of sand and gravel produced is approximately three million dollars, but the amount actually produced is very much greater. I have not spoken of cement, produced to the amount of approximately six million dollars per year; clay products, one million or more; salt, one-half million; lime, one-third million; sulfur, twenty-four million; gypsum, two million; nor of mercury, silver, and associated minerals, one million. The accompanying map (Fig. 1) shows the distribution of the gypsum deposits and the location of plants producing gypsum, cement, lime, salt, sulfur, asphaltic limestone, basalt, fuller's earth, quicksilver, silver, gold, copper, and lead.

Irrigation from Pumped Wells

Underground Water Sources Increasing in Importance as Unappropriated Surface Supplies Dwindle

By Winfield Holbrook

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Well water has a number of advantages over surface supplies for irrigation, among them being its relative invariability in quantity. As surface supplies become more fully appropriated, it will doubtless find increasing use. Even in humid regions, irrigation by wells may be feasible to insure a good crop in drought seasons. Mr. Holbrook here describes briefly the various types of wells and pumps, and takes up the questions of cost, relative merits of irrigation by wells, and its possible future development. This article is an abstract of the paper presented by Mr. Holbrook on April 22, 1937, before the Irrigation Division at the Society's Spring Meeting in San Antonio, Tex.

USE of dug wells as a source of water for irrigation is of great antiquity, though in olden times, when men and work animals were the only source of power, the areas watered were undoubtedly very limited.

"Water Supply and Irrigation Papers of the U. S. Geological Survey No. 1," is the memorable beginning of a long line of valuable publications. This initial pamphlet, entitled "Pumping Water for Irrigation," by Herbert M. Wilson, was issued in 1896. We learn from it that well irrigation had not been attempted to any extent in this country until that time, but that it was then a common practice in older countries. In India, 850,000 pumps were being used in three provinces alone, to irrigate nearly 4,000,000 acres of land from wells.

The large-scale practice of well irrigation in this country began about thirty years ago, and was due largely to four factors: (1) The increasing cost of developing supplies from streams, (2) the need of a supplementary supply for some gravity systems, (3) the improvements made at about that time in prime movers for isolated units, and (4) the introduction of the vertical turbine pump.

Occurrence of ground water in humid regions is so common that it is taken for granted, but in sub-humid and arid regions its occurrence in usable quantities is only occasional. Further, if it is to be used profitably for irrigation, the supply must be at a reasonable depth. Ground water in quantity may be present (1) in the refill of broad stream valleys, (2) in beds of sand and gravel in inland basins, or (3) in a deep water stratum under pressure, which often supplies artesian flow when conditions are right. In this country the first two sources are those more commonly exploited for well irrigation.

The type of well required varies with the mode of occurrence of the water. In artesian areas, the wells are usually of small diameter, and cased with pipe from the top of the ground into the pressure stratum. If the water is in shallow deposits on the impervious floor of a stream valley, it is often necessary to spread the collecting area horizontally, in order to get sufficient volume under the low pressure head. This is done either by digging a well of large diameter or by covering a larger area with several wells all connected with a central pumping pit. The latter arrangement was used on the government project in the Arkansas River valley above Garden City, Kans. Tunnels and trenches have also been used to provide additional water-collecting surface for shallow wells. For wells in a deep, thick formation of water-bearing strata, vertical area is depended upon to furnish the flow under the pressure created by the drawdown of the pump.

Water-bearing formations are often a combination of firm sandstones or conglomerates, loose gravel, gravel and sand mixtures, and unmixed sand, often quite fine. In drilling deep wells, both the drop rig (or spudder type) and the rotary drill are used. If the formations encountered do not cave and the sand is not bad, the drop rig usually is more economical. Under difficult sand conditions, the rotary drill may be faster and cheaper; it provides a much better hole for casing, and is less likely to produce a crooked hole. For large wells, up to, say, 36 in. diameter, the rotary-drill hole is preferable.

It is usually imperative to case a deep well. The usual practice is to use "blank" casing down into the water-bearing formations, and "screen" casing below that point. "Graveling" is a practice supplementary to the use of casing. In wells designed on this plan, the hole is made considerably larger than the casing, and the intervening space is filled with gravel. The fill serves two purposes: (1) It holds back caving ground and protects the casing against collapse, and (2) it holds back some of the sand.

Sand that cannot be held back from the well must be pumped out; this process is termed "developing the well." It is often accomplished by using a larger pump than the one intended for permanent use, or by accelerating the pump to get a larger flow.

The reciprocating pump, although an efficient machine, is not in wide use on large irrigation wells. Lifting with compressed air is generally inefficient, though a modification of the air lift is sometimes used in the natural gas fields to develop water wells. In such cases the gas is

Developing a Water Well with Natural Gas Pressure
The 10-In. Pipe Is Discharging 4,000 Gal per Min

applied under its natural pressure, through a small pipe inside the discharge casing, and the lowered specific gravity of the water column brings out the water and sand.

For low lifts, where the pump can be set close to the water level and the draw-down is small, the ordinary horizontal centrifugal pump is often used with good economy.

However, the vertical turbine pump has won full favor among irrigators as the preferred type for general use. The pump bowls are set deep in the well. The drive

AN INEXPENSIVE FARM PUMPING UNIT

shafting goes down the center of the discharge pipe, and the pump head is installed at the surface of the ground. The diameter and the pitch of the impeller blades, together with the pump speed, determine the pressure developed by each impeller, and thus the proper number of impellers can be selected to give the required lift.

Windmills have been used to some extent to pump water for irrigation. In the western half of the United States, a total area of about 100,000 acres of home gardens is irrigated by perhaps half a million small windmills. However, the larger sizes have not come into high favor because of the undependability of wind power. When they are used it is common to provide an earthen storage tank on the surface, so as to accumulate enough water to get a larger irrigation head.

Steam engines were used as power to drive pumps years ago, but are practically never installed for irrigation use at present. Internal combustion engines fueled with gas, gasoline distillate, or heavy oil, are in general use; they vary in type from small automobile engines to the highest type of Diesel engines. The electric motor is the type best suited for driving vertical pumps, as it can be simply mounted in a vertical position on an extension of the pump shaft. However, electric power is not always available, and in some cases its cost may be excessive.

Radial engines of the airplane type, mounted flat over the pump head, would be practical for vertical pumps, but no manufacturer has yet cared to go to the expense of pioneering an engine for this use.

If the use of ground water over a large area continuously exceeds the natural replacement, the water table will drop progressively. The rate of permanent lowering depends on many factors affecting both the demand and the supply. For example, one river may recharge its whole valley every time a small rise occurs; another may be so small in proportion to the valley area that such replenishment is far from complete. Also, the requirements of irrigation may be excessive during a cycle of dry years, and very light during periods of more rainfall. Thus irrigation demands are heaviest where there is the smallest amount of replenishment. In time, the lowering of the water level may require an adjustment in the means of diversion. It may become necessary, for example, to lower the pumps and install additional stages.

As for irrigation from surface streams and irrigation from wells, each possesses its own inherent limitations and advantages. The total real cost of water secured from wells is, at present, usually higher than the cost of water from surface sources. But so far as future development is concerned, this relation of costs may not apply. The fact that stream water is the greater carrier of sediment is a factor in favor of gravity irrigation; the silt aids in spreading the water over the land, and may add fertility. (Of course, too much silt may choke out small plants.) No general comparison can be made in the matter of mineral content of well and stream water. Mineral content from either source may be an advantage or a detriment.

The matter of water temperature is often discussed. There is an obvious advantage in supplying plants with fairly warm water. We might expect ditch water to have a slight advantage over well water in the summer, but the advantage accrues to well water the rest of the year.

The salient advantage of well supply is its availability at all times when the crop needs water. Another point in its favor is that the spreading of weed seeds is noticeably less when pumps are used than when the water comes by way of irrigation canals supplied from rivers.

Pumping costs are extremely variable, ranging from $3 to $30 per acre-ft under extreme conditions. The variation is due mainly to the costs of different types of wells and equipment, the total height the water must be raised, and the cost of fuel or electric current.

Pumping costs must be calculated separately for each individual case. The items are best divided into two classifications: (1) Overhead, including interest on investment, depreciation, taxes, and insurance; and (2) operation, including fuel (or power charges), lubrication, repairs, and labor. The overhead items are little affected by the extent of use of the plant. The depreciation charge for a good plant under good maintenance is little more than an allowance for obsolescence. Operating expenses will vary almost in direct proportion to the time the machinery is used.

When the cost of an acre-foot of water has been thus determined, and other farm costs considered, the computations can be extended to determine what crops can be profitably grown. On low lifts, ordinary field crops such as alfalfa, cereals, and cotton may be shown to be profitable. Under high lifts these crops might show a loss, but citrus fruits and high-priced truck and other special crops would still be within the economical range.

There is little waste of water pumped from wells. The irrigator never needs to make a place for the water when his turn comes to take it, as happens under a gravity system. He does not start to pump until everything is in readiness to irrigate, and he shuts down immediately when he is through; he wants to see the expense stop when the job is done.

Expansion of irrigation is at present taking place largely in the arid regions. But it is reasonable to suppose that irrigation may later be extended to more humid regions where present needs are less urgent. Droughts may occur even in areas of heavy precipitation, and in such cases crop yields can be augmented by having supplementary irrigation available. This is particularly true as regards truck growing.

It may even be expected that, in the future, irrigation by pumping (from both streams and wells) will be developed more extensively in the humid than in the subhumid and arid districts.

Highway Planning and Location

State-Wide Surveys and Modern Reconnaissance in Texas; Mexico's Highway Achievements

ADVANCES in methods of highway planning and location on both sides of the Rio Grande were described in detail in three addresses delivered at the Spring Meeting of the Society. All three papers, which are abstracted herein, were presented at a session of the Highway Division on April 22, 1937.

In the first article, Mr. Edwards outlines ways and means used in making a survey of existing highways throughout the state of Texas. This survey, which is still in progress, includes four separate parts—a rural road inventory, a traffic study, a financial survey, and a road-life study. An effort will be made to have the general report, expected to cover about 200 pages, intelligible to public officials and laymen as well as to engineers—a matter too frequently neglected.

Highway reconnaissance by automobile, using a motion-picture camera, is colorfully described by Mr. Wells in the second article. By this means 250 miles of route were covered in four days. The road thus located extends from Marathon, in the northern part of Brewster County, to picturesque Green Gulch in the heart of the Chisos Mountains. Another section, now under construction, runs from the Chisos west and south to Santa Helena Canyon on the Rio Grande.

In the last article of the group, Mr. Blair discusses Mexican highway location and construction methods, as exemplified in the 770-mile section of the Pan-American Highway recently completed from Laredo, on the Texas border, to Mexico City. Other sections of this highway, between Mexico City and the Guatemalan border, are now well advanced. These achievements in difficult terrain indicate exceptional ingenuity and resourcefulness on the part of the Mexican engineers concerned, as Mr. Blair points out.

A State-Wide Highway Planning Survey

By G. G. EDWARDS

MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS

MANAGER, TEXAS HIGHWAY PLANNING SURVEY, AUSTIN, TEX.

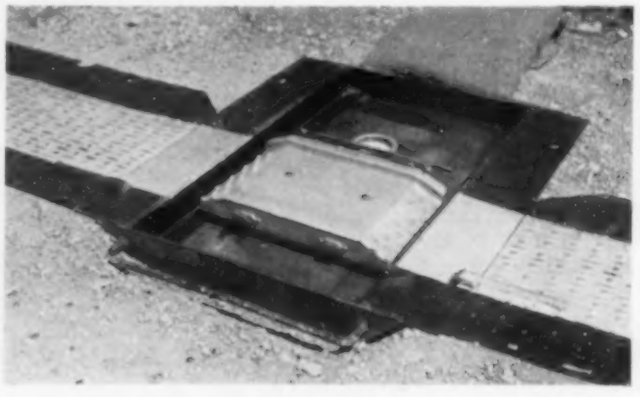
IN April 1936 the Texas Highway Department entered into a project agreement with the U. S. Bureau of Public Roads providing for a state-wide highway planning survey. Similar surveys are under way in more than forty states. They are being conducted in accordance with plans worked out by engineers and economists of the Bureau, as described in an address by H. S. Fairbank, chief of the Division of Information, U. S. Bureau of Public Roads, on January 21, 1937, at the Annual Meeting of the Society. An abstract of this paper was published in the March 1937 issue of CIVIL ENGINEERING. The present paper discusses some of the problems encountered in the Texas survey, which was started in June 1936.

RURAL-ROAD INVENTORY PROVES ECONOMICAL

The field work for the road inventory was started in June 1936. B. B. Freeborough, Assoc. M. Am. Soc. C.E., who has served for many years as resident engineer in the Texas Highway Department, was placed in charge. For administrative purposes, the state was divided into 12 districts. It was our intention to place 6 field parties in each of the 12 districts, under the direction of a district supervisor, and to complete the field work in six months. As the highway department had a heavy construction program under way, this number of competent party chiefs was not available. We therefore started the work with one supervisor and 4 field parties, and expanded the organization as rapidly as possible until our maximum force of 5 district supervisors with 31 field parties was built up. This field work was completed on May 6, and the average cost of this phase of the survey will be approximately 63 cents per mile.

The average number of miles covered per party working day of 8 hours has been 40. Each party consisted of two men working in an automobile. Distances were measured by odometer, and bearings by windshield compass or pocket compass. The parties recorded the type, width, condition of surface of the road, and all visible cultural features. In addition, they made a tape survey of all bridges, ferries, and railroad crossings, and recorded all grades of more than 5 per cent and more than 500 ft in length. The gradometer was a simple affair, consisting of a board from the top of which was suspended a light plumb-bob hanging against a circular scale. When the crude methods and the speed are considered, the results of this phase of the work are very satisfactory.

From these field notes, county maps are being constructed to a scale of 1 in. to 1 mile on polyconic projection. A uniform sheet size of 36 by 50 in. was adopted. In a few large counties where there is not much development, maps are being drawn to a scale of $^1/_2$ in. to 1 mile; and it will be necessary to map some of the metropolitan areas to a larger scale than the standard. A base map is



CLOSE-UP OF LOADOMETER IN PLACE IN THE PIT

LOADOMETER PARTY WITH STATION WAGON AND TRAILER, SHOWING EQUIPMENT IN THE FOREGROUND

made of each county, showing all cultural features and all roads in double lines. Four reproductions of this map will be made on tracing cloth to be used for constructing (1) the general highway and transportation series of maps, (2) the bus and truck series, (3) the school-bus route series, and (4) the postal route series. In addition, we are making a state map on a scale of 1 in. to 8 miles. This will be constructed in two series, the highway map and the transportation map.

So far we have completed only one county base map, at a cost of 65 cents per mile of road, but have carried to the pencil stage the base maps of 42 counties at an average cost of 52 cents per mile of road.

On May 25 two special parties began a study of critical sight distances and curvatures on the state highway system. The sight-distance party consists of three men equipped with two automobiles, who will record by the stadia method all sight distances shorter than 1,000 ft at summits and on curves. The curvature party will measure the degree of curvature and the superelevation of all curves. This will give us a record of all points which are dangerous on account of insufficient sight distance, excessive curvature, or improper superelevation. The work has not progressed sufficiently for the cost to be known, but it is estimated at $1.00 per mile of highway studied.

Information on railroad grade crossings is being obtained from the railroads. This includes a record of the volume and class of train traffic, protective devices installed, and a complete five-year accident record at each crossing. This information, together with that compiled by our field parties, is essential in determining priority of construction of grade separations and protective devices.

TRAFFIC SURVEY MADE BY SAMPLING METHOD

The traffic survey is under the direction of D. K. Shepard, who has had long experience with the highway department as resident engineer. In this survey we are obtaining complete information regarding traffic density and characteristics on all the roads of the state by the sampling method. At 124 loadometer stations and 324 key stations, and at 20 automatic traffic recorders, control data are being obtained which will be applied to 1,000 auxiliary key stations and 13,000 blanket stations, where short counts are made. At the control stations, 14 eight-hour counts are made during the year, twice on each day of the week, with shifts alternating from 6 a.m. to 2 p.m. and from 2 p.m. to 10 p.m. In addition, several night counts from 10 p.m. to 6 a.m. are made at each key station during the year.

Vehicles are not stopped, but are recorded by tallying as they pass the key stations. Here they are also classified as "local" or "foreign" (that is, as state-owned or out-of-state owned), and as "passenger cars," "trucks," or "buses." The direction of traffic is also recorded. Trucks are classified as "light," "medium," or "heavy," and as "trucks," "trucks with trailers," or "tractor-truck semi-trailers." Buses are classified as "school" or "other." Key stations are located on primary roads only. The key recorder is assigned to a district containing 18 stations, which are operated in rotation on a definite schedule. On each report, the recorder indicates any unusual condition which would tend to cause abnormal traffic at that time. These records will give an accurate average 24-hour traffic record for the year at each station. One or more 8-hour counts are made at auxiliary key stations. These counts are then expanded into average 24-hour counts from information obtained at the key stations.

Twenty automatic traffic recorders have been installed at carefully selected points. These record the number of vehicles passing the station. The resulting records, together with the key-station records, will be of great value in working out factors to be used in determining average 24-hour traffic at short-count stations. These machines cost, installed, approximately $575 each, and the cost of operation will be very small, probably about $20 per month per station.

PITS WERE USED FOR THE LOADOMETERS TO PREVENT SHOCK AND FACILITATE PLACING WHEEL IN POSITION

Blanket-count stations are located primarily on local roads, usually at road intersections. They are operated for one day for a period of eight hours, from 8 a.m. to 4 p.m. All passing vehicles are recorded by hours and classified as "local" or "foreign." Traffic is classified as at the key stations. Where possible, all vehicles are stopped to obtain detailed capacity classifications and information as to origin, destination, and ownership. These records when built up by applying factors obtained from the records of the key stations and the automatic traffic recorders, will give a very complete record of traffic on local roads.

Loadometer stations were established at 124 of the key stations. These are operated by special parties, each of which is assigned to a circuit of 18 stations operated on the same schedule as the key stations. Each party consists of a chief, one recorder, two weighers, and a traffic guard, with a station wagon and trailer for transportation. The

key recorder also travels with the party. Data are collected on trucks and buses for each direction of travel, alternating every two hours, except at stations where traffic is light enough to allow the collection of data on all trucks and buses in both directions.

These data include state of registration, license plate number, type of vehicle, type of body, rated capacity, origin and destination, trip mileage, type of origin and type of destination, number of passengers or type of commodity carried, classification of vehicle, loaded weight, carried load, and total weight.

It was the original intention to operate 10 pit-scale stations, at which data would be obtained on buses and trucks as to weights, physical dimensions, tire equipment, and commodities carried, but we found that this information could be obtained at the loadometer stations without materially reducing the size of the samples, and at no additional cost. We are therefore recording the make and year of truck; tire equipment; overall length, height, and width of vehicle, or combination of vehicles; and length of wheel base.

It is estimated that a total of 165,000 vehicles will be weighed at loadometer stations during the survey, including about 121,000 single-unit trucks, 38,000 tractor-truck and semi-trailer combinations, 8,000 buses, and 7,500 passenger cars with trailers. The average number of vehicles weighed and measured per 8-hour shift is 82, and the average cost per vehicle recorded is 60 cents.

Realizing the need for information regarding origin and destination of passenger vehicles using main highways, questionnaire postcards were distributed once on a week day and once on a Sunday to passenger cars passing loadometer stations. The return to date has been about 27 per cent of the cards distributed. The result of this study, in conjunction with the result of the road-use study, may have an important bearing upon questions of highway finance, particularly those involving substitution of motor-vehicle taxes for property taxes and those having to do with relative tax payments of rural and urban residents.

FINANCIAL SURVEY AND ROAD-LIFE STUDY

The financial survey is being managed by J. T. Barton, who came to the survey from the Bureau of Municipal Research of the University of Texas. Its purpose is the collection of data regarding the source and expenditure of highway funds and a general study of all tax collections and disbursements in the various political subdivisions of the state, of which there are approximately 9,000. The study is divided into the motor-vehicle allocation study, the road-use study, and the financial survey proper.

The motor-vehicle allocation study is designed to furnish information concerning the distribution of motor vehicles within the state and the revenue provided to the state through the use of these vehicles, that is, from registration fees and gasoline taxes. This information is being obtained from postcard questionnaires distributed to the vehicle owners through the county tax collectors' offices during the period when license fees are being paid. About 350,000 cards were returned, or approximately 30 per cent of those distributed.

The road-use study phase of the financial survey will obtain, through personal interviews with a carefully selected sample of 2 per cent of the automobile owners and 4 per cent of the truck owners, information regarding the use of state highways, county roads, and city streets by the different classes of vehicles and by rural and urban residents. It will show the benefits of various highway expenditures to the different groups. This phase of the survey has not yet been initiated.

The financial study proper will collect data concerning receipts, disbursements, and indebtedness of all the political subdivisions of the state. The receipts will be broken down into property taxes, motor-vehicles imposts, other special imposts, other general revenues, federal-aid funds, and borrowings, and will be further divided according as to how administered, whether by the state, by counties, by cities, or by special districts. The disbursements will be tabulated as those of the state, counties, special districts, and incorporated places in the different population groups. They will also be broken down into highway, education, public welfare, services, general government, and various types of debt retirement. Highway expenditures will be divided into capital outlay and maintenance costs, and into such costs for state highways, county roads, and city streets.

AUTOMATIC TRAFFIC RECORDER IN PLACE ON HIGHWAY

Several accountants have been working in the different state departments in Austin, and they will later go to the cities and counties for the information not available in state reports.

In the road-life study, the primary objectives are (1) determination of the probable average life and rate of retirement for each type of surfacing in order to be able to forecast necessary reconstruction, and (2) determination of the annual average roadway cost for the several types of surfacing.

This study is being made from the records of the highway department, and covers only the state highway system. The collection and classification of the necessary data is a large task, as there are approximately 12,000 construction contracts to study and records of 13 years of maintenance of about 22,000 miles of highways. Much of the reconstruction and betterment work and some of the construction work has been done by the maintenance department on a day-labor basis. It is estimated that this work will require a total of two years and will cost about $24,000, but it will be of great value to the department in long-range planning. The work was started in November 1936, and as of July 1, 1937, about 2,600 contracts have been studied.

It is probable that the information collected at this time will not be conclusive, since very few miles of the higher types of surfacing have yet been retired, but the records, if kept up to date, will be of great value in the future.

THREE OBJECTIVES OF ANALYSIS

The analysis work is under the general direction of Dr. C. W. Vickery, who came to the survey from the University of Texas, and to whom I am indebted for valuable assistance in the preparation of the remainder of his paper.

In preparing graphs, tables, and other devices of analysis, there are three main objectives to be borne in mind—

highway planning, the determination and allocation of highway cost, and motor-vehicle regulation. Without doubt, in the future, highway cost will be taken more seriously than it has in the past. We must therefore keep before us the objective of determining the road cost of different types of motor-vehicle traffic in a way similar

WEIGHING REAR AXLE OF CAR WITH TRAILER

to that used by the railroads in determining track cost. The problem is more complicated for motor-vehicle traffic than for rail traffic. From the road-life studies, we expect to obtain the life expectancy of the different types of road, and this information, when considered in connection with construction and maintenance costs, should enable us to obtain the average annual cost of each type of road. Correlation of these data with those obtained from the traffic studies should give valuable information concerning the effect of the different types of traffic upon the life of the different types of roads. When these ends have been achieved, it may be possible to require each type of traffic to bear its proper part of the cost of road construction and maintenance.

Data collected in the traffic-density studies will be used in the construction of traffic flow maps, but a large amount of preliminary analysis will be necessary, particularly in the case of the short counts, where conversion factors must be applied to obtain an estimate of the average 24-hr traffic for the year. The preparation of these conversion factors requires a knowledge of the traffic pattern at the point under consideration, which is a composite of both local and remote conditions. This is particularly true of the main arteries serving long-distance traffic. Traffic patterns on primary roads may be entirely different from those of local roads in the immediate vicinity, or even of the roads intersecting it. In order to correlate points having similar traffic patterns, we will have to count traffic at these points and also study the geographic, economic, and social characteristics of the locality.

From the results of the road-life studies we expect to prepare mortality curves similar to those used by life-insurance companies. The mortality of physical plant differs from human mortality in that the date of death is not capable of definite determination and must be fixed somewhat arbitrarily. We must select the date of replacement or resurfacing as the date of death, even though the old road may still possess a considerable salvage value, and in spite of the fact that resurfacing may be done on the old location.

The great part of our analysis work will consist of tabular analysis, done by the punched-card method. This phase of the work is under the direction of S. C. Bailey, who has had long experience with the International Business Machines Corporation and with the accounting division of the Texas Highway Department. When complete, our installation will include 3 key punch machines, 2 verifying machines, 1 reproducing punch, 1 card-counting sorter, and 1 tabulator.

EXAMPLES OF TABLES TO BE PREPARED

We now contemplate preparing 367 table forms, and it is probable that before the completion of the work we shall prepare 500 or more. Among the most interesting of the 28 tables for the road inventory and the inventory as related to traffic studies will be the following:

- Miles of each surface type by width.
- Number and number per mile of restricted sights for each type.
- Number and number per mile, length and length per mile, of excessive curves and grades for each type.
- Number and total length of bridges, classified as to roadway width and condition.
- Number of railroad grade crossings, classified by shortest clear view and type of protection.
- Number and number per one hundred miles of various cultural developments (such as farms, industrial plants, etc.) for each type of roadway.
- Number of miles within municipalities of main route extensions, classified by surface type and width.
- Miles of road, vehicle miles, and average traffic volume per 24 hours on the several highway systems by widths and types of surfaces.

For the financial survey, we contemplate preparing 62 tables, including 17 for motor-vehicle allocation, 20 for road use, and 25 for government cost. Some of the most interesting of these will show:

- Distribution of different types of motor vehicles by population groups, rural and urban, with license fees and fuel taxes paid.
- Miles traveled and gasoline consumed by different types of motor vehicles, by population groups.
- Vehicle miles traveled on rural roads and municipal streets by population groups.
- Correlation of weight and age of automobiles, capacity and age of trucks, with gasoline consumed.
- Receipts, disbursements, outstanding bonded debt, expenditures for bond interest and retirement of bonded debt, of the state, counties, and municipalities, showing amounts applicable to highways, education, public welfare and general government.
- Expenditures for construction and maintenance of different types of highways by population groups.

For the analysis of the loadometer data we expect to prepare 254 tables which will include:

- Movements of commodities by months, by types of vehicles, by origin and destination, and by maximum axle-loads.
- Number and per cent of different types of commercial vehicles in various gross-weight rating groups, capacity groups, loaded-weight groups, etc.
- Relation between rated capacity and carried load, showing tendencies towards overloading.

MEASURING DIMENSIONS OF TRUCK WITH LIVE STOCK

Tire equipment of maximum-load axle of various types of vehicles, of interest from the point of view of road wear.

For the road-life study we expect to prepare 23 tables, among which will be the following:

Miles of each type of road constructed, retired, and transferred from the system each year.
Miles of each type of road remaining in service on January 1 of each year.
Total cost and cost per mile of roadway construction by years.
Cost per mile for maintenance by years.

We expect to prepare a general report of the various surveys for the information of officials concerned, as well as the general public. This report is expected to take the form of a volume of some 200 pages illustrated with a wealth of diagrams, charts, graphs, maps, and photographs. It will summarize and interpret the results in a manner intelligible to the general reader, and will present general conclusions and general recommendations for future improvement. We hope that the general report will be attractive and intelligible enough to occupy a regular place on the desk of every official concerned with public roads in this state, and shall be gratified if the labor and money expended result in more intelligent highway planning and more equitable motor-vehicle regulation and taxation.

WEIGHING FRONT AXLE OF TRUCK CARRYING LOGS

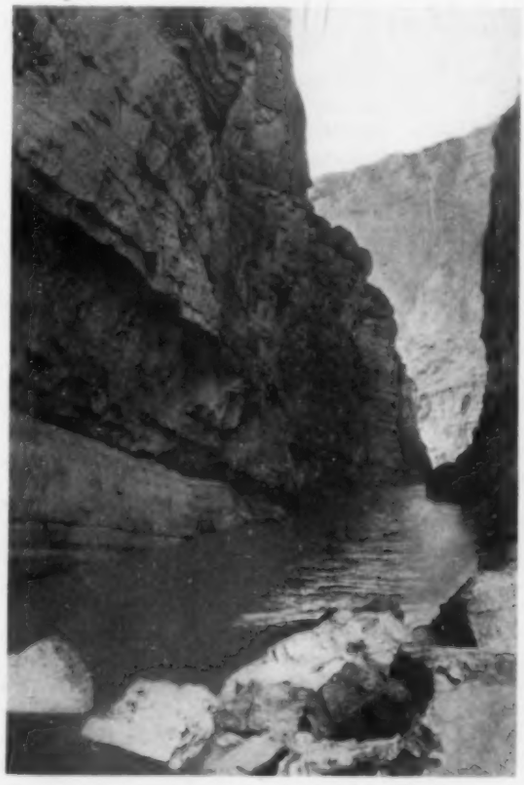
Reconnaissance for the Chisos Highway

By C. D. WELLS
CONSTRUCTION ENGINEER, STATE HIGHWAY DEPARTMENT, AUSTIN, TEX.

THAT part of Texas carved out of Mexico by the downward swing of the Rio Grande is known as the Big Bend country. Prior to 1936 no state highway penetrated this vast land of rugged mountains and plains, chiefly because it is off the beaten track and the population is small and widely scattered.

In the Big Bend country, about twenty miles from the Rio Grande, are the Chisos Mountains, meaning, in the language of the Yaqui Indians, "Ghost" Mountains. They form a crude circle 5 to 6 miles across at the peaks and 15 to 20 miles across at the base, and the depression in the center, known as Green Gulch, is one of the wonder spots of the world. This gulch is 1,000 to 3,000 ft below the surrounding mountains and thus is protected from winter winds and summer heat.

According to Mexican and Spanish legends, the Indian tribes of early days looked on these mountains with awe and each year traveled many hundreds of miles to the outer slopes to hold religious ceremonies. But they never ventured over the rim into Green Gulch. Many caves contain mute evidence of the truth of these legends. However, superstitions meant little to the American pioneers, and we find trails that hardy Texans made in search of gold or adventure.



SANTA HELENA CANYON, THE "GRAND CANYON OF THE RIO GRANDE," WITH WALLS 2,000 FT HIGH

Some of these pioneers came away with the vision of creating a state or national park. And in 1933 their dream approached realization when the state set aside approximately 10,000 acres of land in the heart of the Chisos Mountains as a park. The national government then provided two companies of CCC workers to build a road up through a pass near the Casa Grande and down into Green Gulch. The section was designated as a National Park in 1935 and work was begun to enlarge the park to 1,500,000 acres in Texas and 1,000,000 acres in Old Mexico, thus forming an international park to be known as the Big Bend Park.

MOTION PICTURES USED

In 1936 it became necessary to locate a state highway into this region in order to serve the increasing numbers of people who were clamoring for a means of access. Location of such a highway presented a considerable problem. There were U. S. Geological Survey maps of the entire area, but they did not supply complete information for general location work. The available state funds were limited, and there was not time for the usual reconnaissance survey. Therefore it was decided to make a motion-picture reconnaissance of existing roads and trails, and in this way to select a general location.

The survey was begun in Marathon, a small town about 30 miles east of Alpine, on the Old Spanish Trail. An automobile was used to make the trip, and its speedometer was used in recording distances. Motion pictures were taken at intervals of five miles, or less if unusual conditions or obstacles were encountered. The survey required four days and covered about 250 miles of route, varying from a very serviceable county road serving the

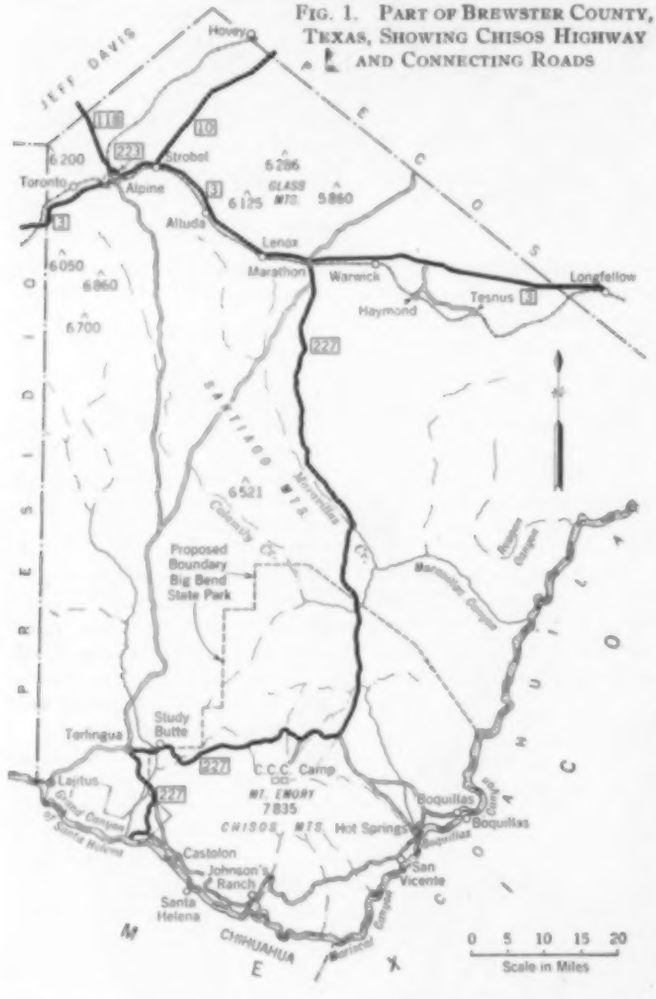


FIG. 1. PART OF BREWSTER COUNTY, TEXAS, SHOWING CHISOS HIGHWAY AND CONNECTING ROADS

town of Terlinqua, to trails that were merely two dim tracks.

As this highway was to serve a traveling public primarily interested in scenery and recreation, it had to afford access to points of interest. At the same time, because of limited funds, it must pass through sections where natural building materials were available if possible, and where grades and curvature were not excessive. Also, excessive excavation and construction of embankments were to be avoided.

We were fortunate in having clear weather during the four days of the survey. The motion-picture work was of course limited to the hours of daylight, but many hours each night had to be spent interviewing ranchers and others who were familiar with the roads and trails so that the work of the next day could be carefully planned. Of course, many side trips were required to investigate different routes. These were generally found to be impractical, and it was necessary to return to the route finally selected; however, complete records were kept of all data developed.

About forty miles south of Marathon a long range of mountains obstructed our progress south—the Santiago Range. Persimmon Gap, which was directly south of Marathon, was found to offer the most accessible pass. It is planned that this pass will form the principal gateway to the Big Bend Park, if and when the entire acreage is procured.

As we emerged from the pass we could see the Chisos Mountains in the distance—about 30 miles south. This section of country is made up principally of gravel deposits or broken stone. There were many deep arroyos to cross, which in time of rain carry a considerable volume of water.

About fifteen miles south of Persimmon Gap we came to an unusual strip of land about ten miles in width, which extends across the Big Bend. It is made up of very unstable clays, and is known as the "Bad Lands." This section is very picturesque because the clays are brightly colored, and erosion has left grotesque shapes, which under the early morning or late evening sun present a continuously changing color picture. As this land becomes unstable when wet, it will be necessary to import surfacing material for the road. Fortunately there is an abundance of such material on both sides of this strip.

A WONDER SPOT OF THE WORLD

As we approached the Chisos Mountains, we noted that they rise abruptly from the mesa which surrounds them. The surrounding land varies in elevation from 1,800 to 2,000 ft above sea level. Mt. Emory, the highest peak of the Chisos range, is 7,835 ft high. A number of small springs flow from the base of the mountains, one of which served as a restful stopping place for lunch. Water from these springs is very often dammed up to form small pools for cattle to drink from. The water is clear, cold, and uncontaminated as far as we could learn; therefore it should serve as an excellent drinking supply. This water may flow from the enormous basin in the mountains, which is thought to be filled with gravel to an unknown depth.

We followed first a dim road around the base of the mountain to the east, which leads down to the sleepy town of Boquillas on the Rio Grande. From here we swung southwest to the small settlement of Hot Springs, also on the Rio Grande. The course of our trip may be seen in Fig. 1. About thirty-five miles to the north we came to the road that leads directly into the Chisos Mountains. As we approached the mountains, the grade increased to approximately 6 to 8 per cent. Leaving the thorn and cactus behind we began to see oak, cherry, and many other varieties of trees. Straight ahead we could see the Casa Grande (Big House), a very beautiful peak. From this point on, the road is being built by CCC workers and is in very good condition.

We went through the pass at 6,000-ft elevation and saw before us Green Gulch, which has an elevation of about 5,000 ft and is completely encircled by mountains except for one small gap, known as the Window, which we could see in the distance. The road ended at the CCC camp, located in the gulch, and to progress further it would be necessary to go on horseback. Hence we spent a day in the saddle to study other possible means of entry into the valley. On this trip we were able to observe many of the features of this beautiful glen which make it unique and worthy of conservation as a park.

The varieties of trees and shrubs are almost numberless; I understand that there are many which have been found nowhere else in the world. There are also many kinds of flowers which have not yet been identified. There is an abundance of game, as well as many species

of the cat family. The types of birds are many and varied. At certain seasons tropical birds of vivid plumage come into these mountains apparently to spend a few weeks. In recent years colleges and universities have learned of the wonders of this spot, and many expeditions of scientists have come to study the plant and animal life, the geology, and other features. The mountains are composed of many types of stone in varying colors—in fact, the most beautiful combination of stone colors that I have ever seen.

After a short rest at Boot Spring, about a mile south of the Laguna, we resumed our journey south, and two miles further on came to the south rim. There we could look down a practically sheer cliff 2,000 ft high, and see the Rio Grande about fifteen miles away faintly glimmering in the sunlight. On this trip we learned that there is only one economical means of entry for automobiles into the valley, and that is the one now being improved by the CCC workers.

As the sun went down we were treated to a beautiful display of colors from the rock walls of the surrounding peaks. Later, when the moon came up bright and clear, we discovered that the coloration of the rock is so vivid that it is visible to some extent by moonlight. Then we saw why the mountains are called Chisos or Ghost, as there is a peculiar silvery light cast over the valley, possibly reflected from the rock walls and rugged cliffs.

As there was a possibility of a better road into the mountains through Alpine and Terlingua, we went west to the quicksilver mining country surrounding Terlingua. About twenty miles from the mountains we came to the little mining town of Study Butte. After passing through Terlingua we swung south towards the Rio Grande, crossing Terlingua Creek, which may prove a very serious obstacle to highway construction as it carries a large volume of water during the rainy season. At present there are no bridges. We soon came in sight of the escarpment which crosses the Rio Grande at almost right angles where Terlingua Creek empties into the river. As we approached within about six miles of the Rio Grande, we saw the break in the escarpment wall which marks the end of the Santa Helena Canyon, but to reach it we had to go down to the Rio Grande and then swing back up the river about three miles. It was possible to follow a narrow trail up one side of the canyon about a half mile.

The motion pictures were properly assembled with titles, indicating the mileage in order that the proper authorities could make their own decision in regard to the location. A study of the data we had compiled indicated that the shortest and most logical location for a road into this country is from Marathon south to the Chisos

A DISTANT VIEW OF THE CHISOS MOUNTAINS, RISING 5,500 FT ABOVE THE MESA

Mountains (Fig. 1) and then, for those interested in seeing the Santa Helena Canyon, west to Terlingua and south to the canyon. Later this road was designated as a state highway, adding 115 miles to the state system. An appropriation of funds was made; maintenance camps were established; construction and maintenance equipment was purchased; and crews placed in charge of conditioning this highway. As there are very few detours, traffic must be carried through construction work; therefore it is being done by state forces. It is properly marked like all Texas state highways. The road is in very serviceable condition as far south as the Chisos Mountains. However, there are large streams to cross on the road extending to the Santa Helena Canyon, which will prove formidable barriers in the wet season until funds are available for the construction of large bridges.

The unusual features of this work are that motion pictures were used in making a record of the condition of existing highways and trails and of the type of country traversed—also to record the type of building materials as evidenced by surface indications. Showings of broken stone or gravel were found along most of the route. It was apparent that there is an abundance of road-building material throughout the entire area.

Highways in Mexico

By JOHN E. BLAIR
DIVISION ENGINEER, STATE HIGHWAY DEPARTMENT, BRYAN, TEX.

A FEW years ago, when we began to hear talk of a great highway to unite all the nations of the New World, making it possible to go by automobile from the United States to the far tip of South America, most of us paid scant attention. The average man thought of this as something that his children might live to see, but which would not become a reality during his lifetime. But this vision is at the point of fulfillment. A great step towards its realization has already been taken, and it is now possible to drive straight south from the Rio Grande a thousand miles over a paved highway. Within two years it should be possible to cross Mexico from north to south, and in several places from east to west, without leaving a paved surface at any point.

The courage, resourcefulness, and energy with which the Mexicans have attacked the problem of pushing motor highways through their rugged mountains are such as to command the admiration of engineers everywhere. The difficulties are many, and the effective resources few. Few motor vehicles are owned in Mexico, and the traffic to be expected, other than tourist, is not large. The general standard of living is far below that of the poorest of our own people. Foreign exchange is at a premium, and goods bought from outside must be used sparingly. Construction machinery is not manufactured in the Republic, and where mountains are to be moved it must be done by the straining of muscles and the lavish outpouring of sweat and blood. Such things as tractors, power shovels, and explosives make quick and easy work, but their injudicious use might bankrupt the enterprise.

To illustrate, a late-model tractor can be bought in this country for a price equal to the wages of 100 common laborers for one month. In Mexico, the equivalent cost would be the wages of about 500 men. Speaking only of

VIEW ON THE LAREDO-MEXICO CITY HIGHWAY

common labor, I judge that one of their men is about equal to two of ours, so that a machine would have to deliver much more work there than it does here to make it equally profitable. Add the interruptions due to the use of machines in remote regions, far from stocks of repair parts, and it is easy to understand why the Mexicans have elected to do everything possible by hand.

Having counted the costs, assayed their resources and capacities, and measured these against the obstacles, the Mexicans made a careful plan, and set themselves to carry it out with great skill and energy. Rumors of big things going on in the remote mountains have been coming to us for several years, and now the project has reached a stage where anyone can go and see for himself.

SECTION OF PAN-AMERICAN HIGHWAY COMPLETED

The most important link in their system, and the only one fully completed, is the section of the Pan-American Highway running north from Mexico City to Laredo, on the Texas border (Fig. 1). This link of about 770 miles is now open for traffic, and is in splendid condition throughout its length. The first section of about 140 miles, from Laredo to Monterrey, has been opened since 1929, and hundreds of thousands of our people have made use of it. Work has been under way on the entire route since the plan was first made, and the delay of more than seven years in completing the southern end will give some idea of the magnitude of the task. The construction consists of asphalt surface treatment on a gravel base, as described hereinafter.

From Laredo south for some 500 miles, the route presents no unusual difficulties, but from Valles to the top of the plateau near Tasquillo, a distance of about 200 miles, the construction involved one of the greatest efforts ever put forth by highway builders anywhere.

Beginning at Tamazunchale, only a few hundred feet above sea level, the road climbs 4,000 ft in less than 30 miles. Within 70 miles the total rise is nearly 7,000 ft. Most of this is on side hill, where in many places the lateral slopes are almost as steep as the natural angle of repose of earth. Because of the steepness of the slopes, tremendous quantities of excavation were required mostly in solid rock.

During much of the year clouds hang low among these mountains, so that the traveler making the ascent enters the clouds from below, drives through them, and comes out again above them. The scenery is magnificent.

Sight distances on this mountain section are short, and the grades are comparatively steep, running up to about 6 per cent. Notwithstanding the slow speeds required, on the mountain section cars are consistently covering the 770 miles from Laredo to Mexico City in one continuous trip of less than 24 hours. This fact gives a general idea of the kind of highway that has been provided.

Having completed this first project, the Mexicans were astonished at the rush of visitors. They are delighted to discover that foreign tourists found their country so interesting. In order to encourage this travel, and make it safe and pleasant to reach all the beautiful and historic spots in the Republic, they are redoubling their efforts to extend the highway system.

Southward from Mexico City to Acapulco, on the Pacific coast, the road is completed except for the asphaltic surfacing. I believe that the hard surface has been placed on about half this section, and work is going forward rapidly on the remainder.

Southeastward, along the route of the Pan-American Highway, the road is completed as far as Tehuacan, for nearly 200 miles. Further along, near Oaxaca, work is now under way, reaching both north and south, closing the gap to Tehuacan on the north and to the Guatamalan border on the south. The round trip from Mexico City to Tehuacan is easily made in a day.

Northwestward, towards Guadalajara, construction is proceeding on a large scale. Mr. Cortes-Herrera, chief of the Mexican Department of Public Works, is authority for the statement that this highway will be a more spectacular accomplishment than the one from Laredo to Mexico City. Although this seems a little difficult to believe, I for one am ready and anxious to be shown. The purpose of this project is to reach the Pacific coast at Mazatlan, and then to proceed northward to connect with the highways of Arizona at Nogales. Another highway is to be built south from El Paso through Torreon, where it connects with an east and west route through Brownsville, Monterrey, and Mazatlan. From Mexico City eastward towards Vera Cruz another road is well along toward completion. These routes form the principal basis of the Mexican system; secondary roads will be added as finances permit.

FIG. 1. SKETCH MAP OF PRINCIPAL MEXICAN HIGHWAY ROUTES

TYPICAL CONSTRUCTION OF ROUTE

The typical construction is a graded roadway about 30 ft in width, consisting of a base of gravel or crushed stone, with a surface of asphaltic oil. Some sections on the earlier work have been surfaced with a "mixed in place" wearing course of road oil, but this does not seem to have been satisfactory, and on later work a double sur-

face treatment of asphaltic cement covered with crushed stone is employed. Their practice differs little from ours in the essentials of design. Owing to the nature of the country they have been forced to spend large sums for grading and bridges, but have kept the investment in surfaces to a minimum by making use of the gravel and stone which abound everywhere. They are not inclined to lay a more expensive type of surface than the traffic requires, and in this respect I think their practice is ahead of ours in some places.

In laying gravel and macadam surfaces, they use fairly large stones, spread them by hand, and compact them with a power roller. In my judgment they would do better to use smaller stone, spread and maintain it with road graders, and allow traffic to compact it. In this way they would secure a more perfect riding surface, at less cost. Their roads would also be more easily scarified and reshaped when reconditioning is required.

Maintenance is not yet as well organized as would be considered necessary with us. Minor holes in the surface do not receive the same prompt attention, but this kind of service costs money. Their energies and resources are now being concentrated on expanding their system; routine maintenance will probably improve as they see this task nearing completion.

In many parts of Mexico cloudbursts are of frequent occurrence. Mexican engineers have become very clever in paving ditches on steep grades, protecting culvert inlets and outlets against scour, and otherwise controlling erosion. All this is done with stone nicely fitted and placed by hand, which lends their work an attractiveness rarely seen in the United Stafes.

Many of the bridges over the larger streams are steel trusses of conventional design, the piers being of concrete. The steel, I believe, is rolled and fabricated in Monterrey, and the work seems to be of about the same quality as that produced in the United States. Solid rock foundations are found at many of the streams, and in such places, especially where clearance is ample, they are likely to prefer a steel arch.

A Stone Arch Culvert on the Mexico City-Puebla Highway
The Road Is Carried on a Long Fill Between Stone Retaining Walls

For minor structures, such as we customarily build of concrete, they frequently use small arches of cut stone. Work of this type is almost a lost art in the United States, but in Mexico it is a joy to behold. I suppose that the skill of their masons, coupled with the fact that such artisans receive little more than the common labor wage, enables them to make use of this beautiful and effective design without neglecting economy and efficiency.

HIGHWAY REGULATIONS AND SIGNS

The visitor to Mexico, if he is at all observant, will be much impressed with the way in which highway laws are enforced. Perhaps I should say "observed," because few signs of enforcement are to be seen. Here we have almost reached the point where the consent of the violators must be secured before any law can be made effective. In Mexico compliance appears to come without forcing. For example, they have signs everywhere warning that it is unlawful to drive on the highway with a vehicle equipped with metal tires. The alternate road, usually alongside, which such vehicles are expected to use, is a

The Laredo-Mexico City Highway near Chapulhuacan

nightmare of mud-holes, rocky ledges, and unbridged gullies. Under similar conditions in our country, would farmers keep their wagons off the smooth paved road and go plunging through the mud? I watched especially for this in Mexico, but in more than 3,000 miles of driving did not see a single violation of the rule.

With us the standard highway sign often contains a couple of bullet holes, and is decorated with poetry penciled by citizens who apparently have nothing else to do. This matter may be covered by a law in Mexico, and it may be regulated by the law of common sense, but the fact remains that a disfigured highway sign in Mexico would be a curiosity. I believe these people simply have enough sense to know that the signs were put up with their own money, and that they will have to foot the bill for replacements.

Concern over safety on the highways is not nearly so evident in Mexico as with us. This may be due in part to the fact that high-speed motor traffic is a new thing with them. Accidents have not yet begun to loom as a national scandal. On the other hand, their attitude may derive from basic differences in point of view. The Mexican regards a human life as of little value, and takes only the simplest measures to preserve it, whether it be his own or another's. He does not subscribe to the doctrine that roads must be made foolproof, so that reckless and foolhardy maniacs will be protected from the results of their own folly. The law of common sense, which governs the Mexican in so many of his routine actions, lays down the proposition that those who drive recklessly where conditions indicate caution will sooner or later catch up with a set of consequences.

Mexican highways are marked with all necessary signs and warnings. But these warnings are not expected to influence the conduct of the reckless; they are there for the sake of such prudent and alert drivers as may wish to take notice of them. A dangerous railroad crossing will bear a sign reading simply "Railroad Crossing." Indeed, what else should it say? The edge of a thousand-foot precipice will be marked with a line of whitewashed stones, like the headstones along a line of graves. The Mexican probably sums it up like this, "The danger is plain for every one to see. The wise will take heed; the foolish will be destroyed."

Design of the San Jacinto Memorial

Poor Soil Conditions Require Very Large Footing for 549-Ft Shaft

By ROBERT J. CUMMINS
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CONSULTING ENGINEER, HOUSTON, TEX.

WHAT is sometimes referred to as the sixteenth decisive battle in world history, fought at San Jacinto on April 21, 1836, between approximately 1,000 Texans under General Houston and a slightly larger force of Mexicans under General Santa Anna, resulted in a victory for the Texans that eventually added nearly a million square miles of territory to the United States. The design of the monument now being constructed on the site to commemorate this victory was complicated by the absence of any rock for foundation purposes. A pleasing octagonal shape was adopted for the shaft, which will be faced with Texas limestone like the rest of the structure. A wind velocity of 125 miles per hr, assumed in the design, will not produce tension at any time in the heavy concrete walls backing the limestone, and temperature reinforcement only was required. The article is abstracted from Mr. Cummins' paper delivered on April 22, 1937, before the Construction and Structural Divisions at the San Antonio Meeting of the Society.

WHEN the Forty-Fourth Legislature of Texas appropriated $250,000 for the erection of a suitable monument on the battleground of San Jacinto, and when the federal government added the sum of $400,000 to this, local interests contributed $40,000 and the Public Works Administration made a grant of $225,000. The committee in charge of the design and erection of the memorial then had at its disposal approximately $900,000 with which to build a monument to commemorate this most outstanding event in the history of Texas.

After several meetings, at which many different plans were considered, it was decided to construct a shaft somewhat on the order of the Washington Monument in Washington, D.C. Around the base of the monument (Fig. 1) will be constructed a museum for the preservation of mementos and relics of the battle itself, as well as other historical relics, particularly those of the early days of Texas.

In the museum building, meeting rooms will be provided for the accommodation of those historical societies which may wish to meet from time to time on this historic spot, and also an art gallery on the walls of which will be depicted the pageant of Texas history for the past one hundred years. There will be niches for statues of those heroes of the past whose names will ever be linked with the history of the Lone Star State.

The scene of the battle was adjacent to Buffalo Bayou—later to become the Houston Ship Channel—near its confluence with the San Jacinto River. This site is now in Harris County, Texas, about 20 miles southeast of the city of Houston.

It was finally decided that the monument should be erected on top of the hill near which Santa Anna's army was entrenched on the day of the battle. Borings were taken to ascertain the nature of the underlying soil. These revealed a bed of stiff red clay extending from 6 ft below the surface to the bottoms of the borings, which were carried to a depth of 100 ft. Tests for the bearing value of the soil at the level of the bottom of the footing, made by Alfred C. Finn of Houston, Tex., architect for the monument, showed a uniformly progressive settlement of the soil under standard plates 2 sq ft in area until the load reached 33,000 lb. Arrangements were also made with the bureau of engineering research of the University of Texas, through Raymond F. Dawson, Assoc. M. Am. Soc. C.E., testing engineer, to conduct tests to ascertain the probable settlement of the structure over a period of years, based on the actual stress on the soil caused by the dead load of the structure.

Several designs were prepared for the foundation. It was found that, in order to keep the soil pressure within the agreed safe limit of 8,000 lb per sq ft, a footing approximately 110 ft square would be needed. After careful consideration it was decided to increase this size so that the outer walls of the museum, which has an outside dimension of 124 by 124 ft, might rest on the outer edge of the footing. This was considered preferable to building the shaft on its own footing and introducing an outer ring or series of isolated footings for the support of the outer walls of the museum.

To exclude excessive moisture from the soil on which the footing rests, and at the same time to provide a satisfactory floor on which to assemble the steel reinforcement, the soil was hand-trimmed to a level surface, and covered with a 3-in. layer of 2,500-lb concrete immediately after exposure to the air. The contractor has since expressed the opinion that this working slab saved much money in the placing of the steel and the pouring of the base.

The base proper was reinforced with bars 2-in. square spaced 6½ in. on centers in each direction, the ends being staggered so as to provide reinforcing at the outer edges. To hold the bars in place during the pouring of the concrete, every tenth bar in the top layer was spot-welded to all bars in the lower layer, an arrangement that worked admirably. The steel was supported on standard steel chairs which insured that the lower layer of bars would be protected by fully 4 in. of concrete beneath it. In addition,

FRONT VIEW OF STRUCTURE, SHOWING TWIN STEEL ERECTION TOWERS AND WORKING SCAFFOLD

a line of welds was introduced at the outer extremities of all bars, each bar being welded to the two outermost bars running at right angles to it.

The reinforcing of the footing (Fig. 2) was determined as follows:

Area of trapezoid	3,225 sq ft
Lever arm	22.5 ft
Upward soil pressure	$\frac{37,200,000}{15,040}$ = 2,500 lb per sq ft
Bending moment	181,000,000 ft-lb
Effective width	100 ft approximately
Bending moment in ft-lb per ft of effective width	1,810,000
Steel needed	$\frac{1,810,000 \times 12}{174 \times \frac{7}{8} \times 20,000}$ = 7.15 sq in.

As far as known, the length of the bars furnished (110 ft), and their number (426) constitute a record for length and tonnage placed in one isolated footing. The bars were handled with ease by means of an auxiliary cradle 50 ft long, on the end of the 45-ft boom. Only a very few bars were bent in the handling, and these were straightened out with a standard rail bender.

The footing proper contains 5,600 cu yd of concrete. While it is not anticipated that any uneven settlement will ever take place in it, a small amount of reinforcing was introduced in the upper face near the outer edge to safeguard against such a contingency. The pouring of the footing itself was made with two mixers, each of 30-cu ft capacity, the buckets working on an extended boom reaching to the center line of the footing from opposite banks. The pouring was done in a continuous operation lasting for 60 hours, making an average pour of over 90 cu yd per hour.

CONSTRUCTION OF WALLS AND FLOORS

A basement wall 12 in. thick rests on the outer edge of the footing and supports the first floor and roof of the museum. Intermediate columns resting directly on the footing help to support the museum's first floor but do not extend above it. Concrete roof beams span the full 38 ft between the outer walls and the shaft.

The museum has a clear height of 30 ft, giving a very spacious effect in keeping with the massiveness of the structure. The floor and roof were made monolithic with the shaft, as it was felt that the movement of the latter would be so slight as to make unnecessary a ring around it to prevent transmission of movements to the rest of the structure. In the basement are located a boiler room for heating the museum, and comfort stations for visitors.

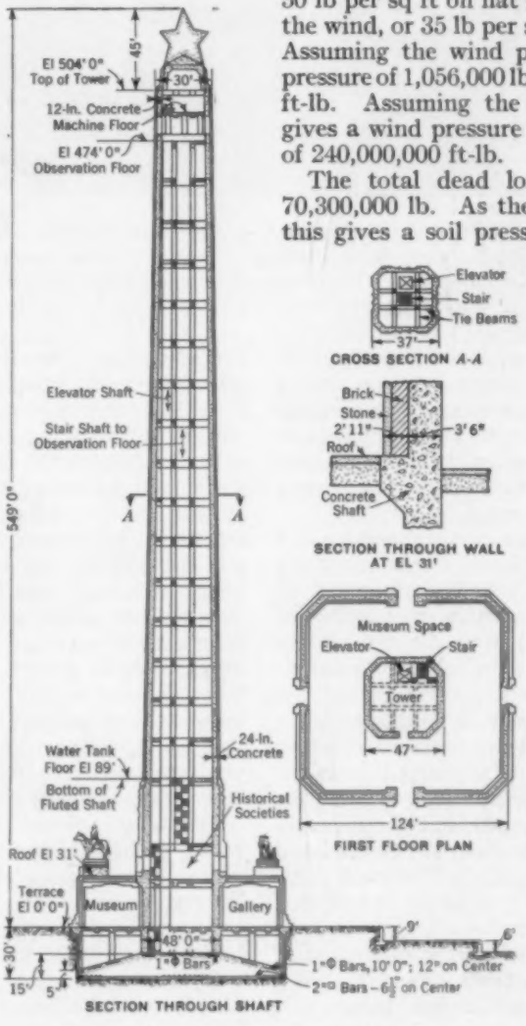

FIG. 1. SECTIONAL ELEVATION AND CROSS SECTIONS OF MEMORIAL TOWER AT SAN JACINTO BATTLEGROUND, NEAR HOUSTON, TEX.

Before pouring of the base was started, the research department of the University of Texas established a number of benches at 50 different points on the footing. In this way an accurate determination can be made of any settlement at various points throughout the area. It is felt that these data will be of great value in establishing the distribution of stress under an isolated footing of unusually large area.

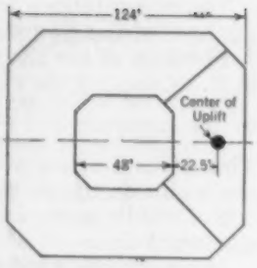

FIG. 2. PLAN OF FOOTING, SHOWING LOCATION OF CENTER OF UPLIFT

The shaft is octagonal in shape, consisting of a square with the corners cut off. It is 47 ft across at the base and 30 ft across at the top. The distance from the top of the foundation to the top of the shaft on which the five-pointed star will stand is 519 ft. The height of the star is 45 ft, giving an overall height of 564 ft. As the top of the footing is 15 ft below the first floor, the height from the first floor to the extreme top of the monument will be 549 ft.

TOWER DESIGNED FOR A 125-MILE WIND

In computing the stresses due to wind, a wind velocity of 125 miles per hr was assumed, producing a pressure of 50 lb per sq ft on flat surfaces normal to the direction of the wind, or 35 lb per sq ft on surfaces inclined at 45 deg. Assuming the wind parallel to two sides gives a wind pressure of 1,056,000 lb and a wind moment of 270,000,000 ft-lb. Assuming the wind parallel to a shaft diagonal gives a wind pressure of 960,000 lb and a wind moment of 240,000,000 ft-lb.

The total dead load of the structure amounts to 70,300,000 lb. As the base has an area of 15,040 sq ft, this gives a soil pressure of 4,700 lb per sq ft. If the wind is blowing in a direction parallel to two sides, soil pressure is increased to 5,600 lb per sq ft, obtained by substituting in the formula $\frac{W}{A} \pm \frac{Mc}{I}$, the quantities

$$\frac{70,300,000}{15,040} \pm \frac{270,000,000 \times 62}{18,700,000}.$$

If the wind is in the direction of a diagonal of the shaft, the maximum soil pressure is 5,700 lb per sq ft, obtained by substituting in the same formula the quantities

$$\frac{70,300,000}{15,040} \pm \frac{240,000,000 \times 78.5}{18,700,000}.$$

Because of architectural requirements, the walls of the shaft at its base were made 48 in. thick. This is in excess of the thickness needed to sustain the load and keep the unit compressive stress of the concrete within safe limits. But it seemed desirable to introduce a wall thickness in excess of theoretical requirements, and this condition prevails in general throughout the height of the shaft. Where the fluted section begins, at El. 89, the walls of the shaft are 24 in. in thickness and diminish gradually to 12 in. at the top of the shaft.

The computations for concrete stress in the shaft at the level of the ground floor were as follows:

The area of the shaft at the ground-floor level is 640 sq ft. Assuming the wind parallel to two sides, the stress in the concrete is $\frac{37,200,000}{640} \pm \frac{270,000,000 \times 23.5}{187,000}$. This gives a stress of 640 lb per sq in. on the lee side, and one of 160 lb per sq in. on the windward side.

Assuming the wind parallel to a diagonal, the stress in the concrete is $\frac{37,200,000}{640} \pm \frac{240,000,000 \times 28.2}{187,000}$. This gives a stress of 650 lb per sq in. on the lee side, and one of 150 lb per sq in. on the windward side.

Similar computations made at El. 89, where the fluted shaft begins, give the following stresses:

Assuming the wind parallel to two sides gives a stress in the concrete on the lee side of 740 lb per sq in., and on the windward side, of 100 lb per sq in. Assuming the wind parallel to a diagonal gives a stress in the concrete on the lee side of 780 lb per sq in., and on the windward side of 70 lb per sq in.

VIEW OF TOP OF THE SHAFT AT ELEVATION 54

The Stone Facing at the Right Serves as a Form for the Concrete Wall. The Groove in Its Surface Is to Be Used for the Insertion of Galvanized Anchors

CONSTRUCTION OF THE SHAFT

Above the roof of the museum, the shaft is faced for a height of 58 ft with a stone veneer varying in thickness from 6 to 16 in. and backed solid with brick. A part of this height will be taken up by a continuous sculptured panel 16 ft high, on which it is planned to depict in bas relief the history of Texas from the date of the battle to present times. The roof of the museum has been designed to support massive sculptural groups, one on each side, centered on each axis of the monument.

At El. 89 the stone facing merges into a fluted veneer 4 to 5 in. in thickness, on buff-colored Texas limestone with shell markings throughout. This limestone, which is being mined at quarries near Austin, is capable of taking a very high polish, and when so treated closely resembles travertine marble. It is the architect's intention to give this limestone a high polish inside the museum, bringing out the full beauty of the stone.

In constructing the shaft the contractor plans erecting a band of stone veneer 6 ft in height. Using this as the front form of the concrete wall, he proceeds to pour the concrete against it. Tests have shown that the concrete will not stain the stone and that an almost perfect bond takes place between the two materials. However, positive anchorage is established by means of hot-dipped galvanized anchors, spaced 2 ft apart each way.

The computations show that the shaft is of such size, and the walls of such thickness, that under the wind load for which the structure has been designed there will never be any tension in the concrete. Therefore the walls have been reinforced vertically and horizontally with steel for expansion and contraction stresses only.

At 24-ft intervals throughout the height of the shaft, two concrete beams are introduced in each direction for the support of the concrete stairs and the anchorage of the elevator guides. These beams are poured monolithic with the walls of the shaft and are utilized by the contractor for the support of a working platform. The shores from the series of beams below are allowed to remain in place until the freshly poured beams have fully set.

The elevator serving the souvenir floor (El. 451), and observation gallery (El. 474), is of a slow-speed type and will make the trip from the ground to the top floor in about two minutes. It is anticipated that the revenue derived from taking sightseers to the observation gallery will help greatly in defraying the expenses of upkeep for the shaft and the museum. A machinery floor is provided at El. 492.

STAR LOOKS THE SAME FROM ALL DIRECTIONS

The roof over the machine floor constitutes the base for the unique star which tops the monument. Modeled after the star on the state flag, this device is so formed that viewed from any point of the compass it presents the appearance of a five-pointed star. The star is 45 ft high and terminates in a beacon light fitted with two 500-w lamps for the guidance and protection of airplane pilots.

The contract for the building of the monument, which was awarded in June 1936 to the W. S. Bellows Construction Company of Houston for $758,300, calls for completion in 400 working days. Work is progressing steadily, and the contractor has assembled much of the stone to be used to face the shaft throughout its height.

Two terraces will be provided. The first will be 244 ft square. The second, at a level 9 ft lower than the first, will be 364 ft square. These terraces surround the entire structure, simulating a massive pedestal on which the museum and shaft will appear to rest. In the rear there will be an amphitheater with an outdoor stage and seats for 5,000 people. This amphitheater, as well as the terraces, will be built as a WPA project. A reflecting basin 220 ft wide and 2,000 ft long, to be located in front of the tower, will also form a part of the WPA project. The basin will be flanked on each side by stately trees, thus providing a suitable setting for the shaft.

When completed the monument will undoubtedly prove a mecca for thousands of visitors not only from Texas but from every state in the Union. Lovers of liberty the world over will wish to view the shrine erected by a grateful people to the memory of the immortal heroes who fought and died at this place.

The cornerstone was placed April 21, 1937, by Jesse H. Jones, chairman of the Reconstruction Finance Corporation, in the presence of a great assembly of national and state officials and representatives of political and fraternal orders from many sections of the state.

Ground and Surface Water Problems

With Particular Reference to the Development of Water Resources in Texas

RIVERS that disappear into the ground, cloudbursts that transform small creeks into torrents rivaling the Ohio in flood, great artesian reservoirs, and scattered underground pools of salt water—all give a special zest to the study and development of the water resources of Texas. And with these resources already taxed to the limit in many localities, Texas may rightly look upon such study and development as a matter of immediate and paramount importance.

Much work has already been done. The orderly development of six main watersheds has been made possible by the organization of watershed districts. A great deal of information on surface water supplies, including data on flood flows, has been collected. An intensive survey of ground-water resources has been in progress for several years, with the principal object of determining the safe yield of underground reservoirs.

Much work, however, remains to be done. Surface water investigations should be made at many additional points. The number of rainfall stations is sadly deficient for the detailed studies required for flood-control and similar projects. Law and policy and procedure in respect of watershed development are not yet adequately defined. The subsurface investigations are far from complete.

All of these matters are treated in the following articles, abstracted from papers presented before the Irrigation Division at the 1937 Spring Meeting.

Investigating Ground-Water Resources

By SAMUEL F. TURNER

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GROUND water differs from other underground resources in that it is continually replenished by precipitation and by seepage from streams. If the withdrawals from underground reservoirs do not exceed safe limits, the supply of water will last indefinitely. Ground water is one of the principal natural resources of Texas; about 80 per cent of the people of the state are supplied with drinking water from wells or springs, and 90 per cent of the public supplies are derived from wells. As development of the state continues, there will be constantly increasing demands upon the ground-water resources. If the consequences of overdevelopment are to be avoided, accurate information regarding the quantity of ground water in various sections must be obtained, and the most effective methods of utilizing and conserving it must be developed.

In 1929 an investigation of the supplies in the Winter Garden area near Carrizo Springs, Texas, was begun. Since then other areas have been surveyed, and it is planned to continue the investigations until the ground-water resources of the entire state are known. The Winter Garden investigation was undertaken by the Texas State Board of Water Engineers and the U. S. Geological Survey in cooperation with the engineering experiment station of the Agricultural and Mechanical College of Texas. The State Department of Health has assisted by making studies of the sanitary condition of the ground water; and well-logs, maps, and geologic reports have been furnished by the State Bureau of Economic Geology. The State Bureau of Industrial Chemistry has cooperated in the chemical studies. All these studies have been made possible through appropriations made by the state legislature, allocations of federal funds to match the state appropriations, and special allocations under the federal Administration of Public Works and the Works Progress Administration.

This work has occupied the full or part time of 5 to 25 geologists, engineers, and chemists. The investigation is under the general supervision of O. E. Meinzer, geologist in charge, Division of Ground Water of the U. S. Geological Survey, and the immediate supervision of Walter N. White, hydraulic engineer of the same organization.

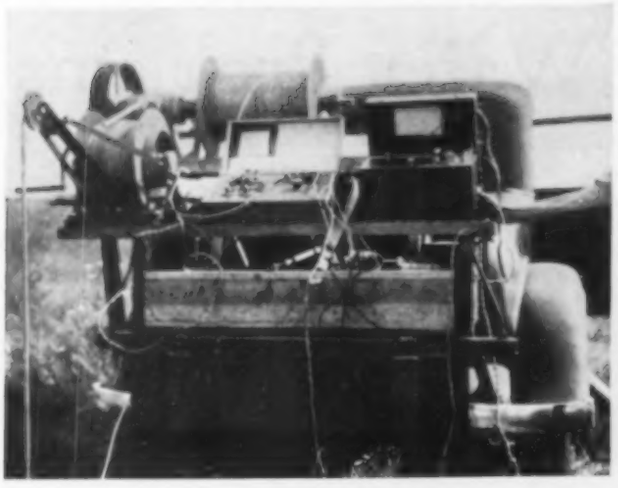
TYPES OF GROUND-WATER INVESTIGATIONS

The work has consisted of reconnaissance investigations, well inventories, and detailed investigations having as their principal object the determination of the safe yield of the underground reservoirs. Among the regions already covered by detailed studies are (1) the Houston-Galveston area, where an average of about 80 mgd is pumped from wells for municipal and industrial uses and the equivalent of a continuous flow of 15 to 20 mgd is pumped for the irrigation of rice; (2) the San Antonic area, where the discharge from wells and springs averages about 100 mgd; and (3) the Winter Garden area, where about 25,000 acres of winter vegetables and citrus fruits are irrigated from wells. Reconnaissance investigations consisting of a rapid study of the geology and ground-water conditions of relatively large areas have been made in the Texas Panhandle and other parts of the state.

An essential part of all the ground-water investigations has been the collection of as much information as practicable concerning wells and springs and the quality of the water they yield. Such inventories have been made or are in progress in 43 counties widely spaced throughout the state. First, the wells and springs are correctly located on the most accurate base map obtainable; then a full description of them is recorded and water samples are collected for analyses.

It has been found that the best method of studying the quality of the water is first to make partial laboratory analyses of 8-oz samples from a large number of wells and springs. Determinations of the alkalinity, hardness, and chloride and sulfate content usually are considered sufficient. After the results of the partial analyses have been studied, complete analyses are made of gallon samples collected from representative wells and springs properly spaced throughout the area.

Many special ground-water problems have been disclosed. In such cases the geology is carefully studied, special attention being given to the principal water-



APPARATUS FOR LOCATING SALT-WATER LEAKS
At Left, Power-Driven Winch to Handle Electrodes. At Right, Hand-Operated Set, Used in Kleburg County, Texas

bearing beds. The outcrop areas of these beds are mapped, and their character, thickness, and dip are studied both in the outcrop areas and down the dip where they are under cover. Where the ground-water resources have been developed extensively, the main problem usually is to determine the amount of water that can be safely withdrawn each year. Next in importance in some areas, as in the Winter Garden, is the problem of the increasing mineral content of the water in some of the wells. Where mineralization has increased, it is necessary to determine whether the supply from the fresh water-bearing beds has become mineralized, or whether the casings have developed holes which admit water from beds that normally contain highly mineralized water. In some areas the waste of water from wells, either above or below the surface, is large enough to endanger the available supply. The source of such wastage must be located and the amount measured in order that remedial measures can be applied.

In his "Outline of Methods for Estimating Ground-Water Supplies" (U. S. Geological Survey Water-Supply Paper 638-C, pages 99–144, 1932), O. E. Meinzer states: "The most urgent problems in ground-water hydrology at present are those relating to the rate at which the rock formations will supply water to wells in specified areas—not during a day, a month, or a year but perennially. The permeable rock formations may be regarded as underground reservoirs or as underground conduits. Some water-bearing formations function chiefly as reservoirs, others chiefly as conduits, but all of them have some of the properties of both. In attempting to solve the quantitative problems above mentioned, these two functions of rock formations must be recognized and differentiated. Quantitative methods based on the reservoir conception are applicable chiefly, though not exclusively, to formations or parts of formations that have water tables; methods based on the conduit conception are applicable most largely to artesian formations, in which the water moves laterally considerable distances from the intake to the discharge area."

There are two factors that may limit the amount of ground water to be withdrawn safely from a stratum in any area, (1) the average annual recharge to the stratum, and (2) the capacity of the stratum to transmit the water to the pumped area. In some areas, such as Houston and vicinity, the transmission capacity of the water-bearing sands is the limiting factor; in others, such as the Winter Garden, the average annual recharge on the outcrop of the water-bearing sand is the limiting factor.

In studying the safe limits of ground-water withdrawal in Texas, three quantitative methods are used; these may be called the recharge method, the transmission method, and the discharge method.

THE RECHARGE METHOD

In the recharge method an attempt is made to measure the recharge to the water-bearing stratum in the outcrop area. This area is mapped and the thickness and character of the water-bearing bed are determined. An inventory of wells and springs on the outcrop is made and a number of wells, preferably those that are not pumped, are chosen for observation. As a basis for determining the rise of the ground-water levels in response to precipitation, and for estimating the recharge, the water levels in the observation wells are measured at regular intervals, generally weekly or monthly. In some cases automatic water-stage recorders are installed. Rain gages should be maintained near the observation wells in areas not adequately covered by stations of the U. S. Weather Bureau. Stream measurements are made at different stages, above and below the points where the streams cross the outcrop, and the losses or gains in flow are studied.

In some of the work, soil tubes have been used on selected plats to study the movement of the soil moisture. One-inch cores are taken from selected depths at uniform time intervals, and the moisture content of the soil samples is determined. Thus the rate of penetration of the rainfall and the amount of water that is moving downward through the soil can be measured.

Lysimeters were used in a few places. They were installed by digging a shaft to a depth of 10 to 15 ft, and near the bottom of it tunneling out a distance of 4 to 6 ft and then jacking a metal container against the top of the tunnel. These containers, or lysimeters, were filled with material excavated from the tunnel and were weighed just before they were installed. The tunnel and shaft were refilled and after periods of varying length, depending on the amount of rainfall, were reopened and the lysimeters were removed and weighed. The gain in weight indicated the amount of water that had penetrated to their level. This water, it was assumed, would have penetrated to the water table if it had not been intercepted. The results of these tests were not very satisfactory, principally, perhaps, because of the effect of trapped air in the lysimeter. It is believed, however, that this method deserves further investigation.

THE TRANSMISSION METHOD

In the transmission method, the capacity of the water-bearing strata to transmit water from the outcrop or recharge areas to the pumped areas is studied both in the field and in the laboratory. Samples of the water-bearing sands were obtained from wells and test pits on the outcrops of these sands, and by core drilling in

deep wells. These samples were tested in the laboratory to determine the percentage of voids, the coefficient of permeability, and other physical properties. Field determinations of permeability were also made, in some cases, by the "Thiem's test." In such a test one well is pumped and its discharge is measured, and the drop in the water levels in two or more other wells within the area of influence is observed. The coefficient of permeability may be defined as the rate of flow at 60 F through a cross section of 1 sq ft under a hydraulic gradient of 1 ft in a distance of 1 ft; or as the corresponding flow through a cross section 1 ft deep by 1 mile wide when the hydraulic gradient is 1 ft in a distance of 1 mile. It is computed by the formula,

$$P = \frac{527.7\, q \log_{10}(a_1/a}{M\ (s - s_1)}$$

where P is the coefficient of permeability in gallons per day; q is the rate of pumping, in gallons per minute; a and a_1 are the respective distances of two observation wells from the pumped well, in feet; m (for artesian conditions) is the vertical thickness of the water-bearing bed, in feet; m (for water-table conditions) is the average vertical thickness, at a_1 and a, of the saturated part of the water-bearing bed, in feet; and s and s_1 are the drawdowns at the two observation wells, in feet. The average of three tests made in this manner in widely separated localities in the Winter Garden area checked closely with the average coefficient of permeability given by the laboratory tests on the cores and well cuttings.

In applying the transmission method, the pressure heads or static water levels in a large number of wells, both in the outcrop areas and in the pumped or discharge areas, are determined, and a map of the piezometric or pressure-indicating surface is compiled.

The results are computed as follows. The average permeability of the sands is computed from both laboratory and pumping tests, and the hydraulic gradient is taken from the piezometric map. One of the lines of equal pressure between the outcrop and the discharge areas is selected for computing the cross-sectional area of the water-bearing bed. The length of the line is measured on the map, and the average thickness of the sands along this line is estimated from well logs. With these data the quantity of water passing through the cross section can be computed. In the Winter Garden district, a 60-mile section along the 550-ft pressure contour was selected (Fig. 1). It is estimated that along this contour the average thickness of the formation is 200 ft, the average coefficient of permeability 200, and the average hydraulic gradient 10 ft to the mile. With these data the computations give an average velocity of the water of about 50 ft a year, and a total flow of about 24,000,000 gal a day (27,000 acre-ft a year).

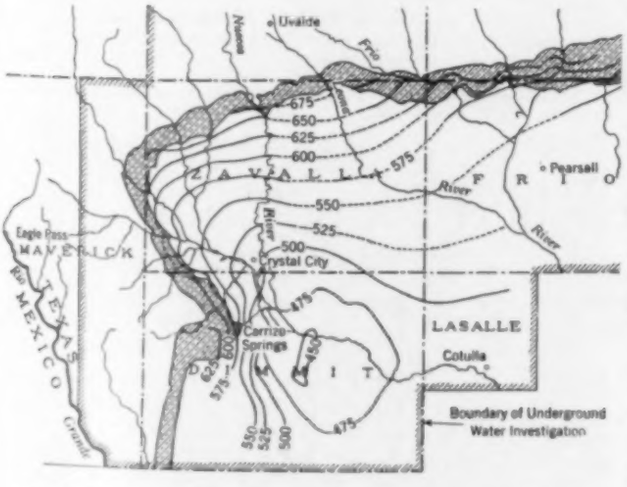


FIG. 1. MAP OF WINTER GARDEN AREA, IN SOUTHERN TEXAS
Showing Outcrop of Carrizo Sand and Lines of Equal Artesian Pressure (Piezometric Surface)

THE DISCHARGE METHOD

In applying the discharge method, fluctuations in the water table or artesian pressures in the areas of discharge are studied and correlated with fluctuations in the total discharge over a period of years. Observation wells are selected and either measured at frequent intervals or equipped with continuous water-stage recorders. Periodic or continuous measurements of the discharge from large springs and flowing wells are made and periodic inventories of the pumpage are taken.

Pumpage inventories are difficult to make, and various more or less indirect methods have had to be employed. In the majority of cases, in cities and industrial districts, the pumpage has had to be estimated by measuring the discharge of the pump and obtaining from the person most familiar with its operation an estimate of the length of time each month the pump was operated. In some of the smaller towns the public water-supply pumpage was estimated from the number of consumers.

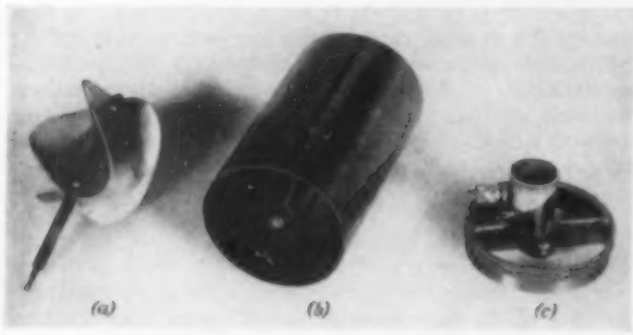
In farming areas, pumping tests were made on certain wells that were used to irrigate a field of known size in which only one kind of crop was raised. The discharge of the pump and the consumption of electrical power or fuel per unit discharge were computed. From these figures and from records of the power company of the total amount of power consumed during the pumping season, the consumption of water per acre, or duty, for the particular kind of crop involved was estimated. Then all the irrigated land in the district was mapped, the total area in each kind of crop computed, and a figure for the total pumpage obtained.

The discharge method is probably more reliable than either the recharge or the transmission-capacity method when long records of discharge and water-level fluctuations are available.

METHODS USED IN INVESTIGATING SALT WATER LEAKAGE

In some parts of Texas, beds containing highly mineralized water overlie the sands containing fresh water. The mineralized water is likely to corrode the well casing and enter the well through the opening thus formed. Such corrosion has ruined many wells, and has resulted in some local contamination of the fresh water beds themselves. In one area in south Texas, the average life of a steel casing has been about four years, and heavy iron casings have lasted only eight to ten years. However, casings protected with a heavy layer of cement on the outside have not developed leaks.

Methods for discovering the location of salt-water leaks include, (1) sampling the water at different depths, and (2) measuring either the resistance or the conductivity of the water at different depths. The later scheme was developed by P. P. Livingston, M. Am. Soc. C.E., and W. A. Lynch, in their work in the Winter Garden area. In brief their method consists of lowering into the well a pair of electrodes attached to the bottom of a two-conductor insulated cable and measuring the amount of current transmitted through these electrodes. Dry-cell batteries furnish the necessary electric current. When these electrodes encounter water with increasing salinity, the amount of current transmitted increases very rapidly, and this increase is indicated on a micro-



A DEEP-WELL CURRENT METER
(*a*) Turbine Wheel, (*b*) Meter Case with Lower Bearing, (*c*) Upper Bearing with Commutator Head

ammeter. If possible, before starting this test, the well is pumped until the salt water condition has cleared up as nearly as possible. When the pump is shut off, a zone of salt water forms in the well at each leak. As many as seven distinct leaks at different depths have been discovered by this method. Often when the leaks are at a shallow depth, the casings can be repaired and the original quality of the well water restored.

The use of the deep-well current meter, as developed in Hawaii and in Roswell, N.Mex., was tried in Texas, but it was of little value in detecting leaks, as the amount of inflow is usually too small to register.

It has been found that salt water will enter a flowing well and contaminate the fresh water even though the salt water is under less head than the fresh. Apparently this is partly due to the greater specific gravity of the salt water and partly to the fact that when the hole is first eaten through the casing, the fresh water in the well, being under greater pressure than the salt water, flows out of the hole and soon builds up an almost equal pressure in the salt water on the outside. The fresh water floats on top of the salt water, and when equilibrium is practically reached, the fresh water flows out of the casing at the top of the hole and salt water enters at the bottom, or through another hole lower down.

A typical example of this condition was noted in Kenedy County, in a 6-in. well with a flow of approximately 60 gal per min of good water. The water gradually became salty and the flow finaly stopped, the last flowing water being so heavily mineralized that stock would not drink it. After several months the well was repaired by inserting a 4-in. casing and setting packers between the casings. When the new string of casing passed the leak, at approximately 80 ft below the surface, a slight flow of very salty water started through it. The flow gradually increased and the quality of the water gradually improved. After several months, the flow had increased to 40 gal per min and the water was practically as good as it had been before the leak developed.

OTHER SPECIAL PROBLEMS

Salt-water encroachment from the Gulf has been reported in a few areas in Texas. The first step in an investigation of such a condition is to obtain water samples from practically all the wells in the area under observation. The samples are analyzed for their chloride and sulfate content. Selected wells are examined to make sure that leaky casings are not influencing the quality of the water; then these selected wells are resampled at intervals for several years to see whether the mineral content of the water is changing. A study of this kind is now being made in wells of the Houston area and in a line of wells from Houston to Galveston. Preliminary sampling has been done in Victoria, Calhoun, Kleberg, and Kenedy counties and other parts of the Texas coastal plain; the results thus far have not indicated salt-water encroachment in any area.

In several areas in Texas there have been large losses of water from the artesian strata. For example, leakage from artesian wells has almost water-logged the area immediately adjacent to the town of Pecos, and in the San Antonio area water from the Edwards limestone, which is under heavy pressure, is escaping in places into the overlying Austin chalk and Leona gravel through defective well casings. Leaks of this kind, if they are of considerable magnitude, can be detected by means of the deep-well current meter. The velocity of the water is reduced by a leak, provided the size of the casing is the same above and below it, and therefore a rapid rise in velocity as the meter is lowered into the well indicates that it has passed below the leak.

Persons interested in the ground-water resources of Texas will find much valuable information in the following publications:

"Water Resources of the Edwards limestone in the San Antonio Area, Texas," by Penn Livingston, M. Am. Soc. C.E., A. N. Sayre, and W. N. White, Water-Supply Paper 773-B, 1936.

"Ground-Water Resources of Kleberg County, Texas," by Penn Livingston and Thomas W. Bridges, Water-Supply Paper 773-D, 1936.

"Survey of the Under-Ground Waters of Texas," by O. E. Meinzer and W. N. White, February 16, 1931. (In this report a summary is given of the principal results of the investigation from September 1929 to January 1931, with special reference to the data obtained in the Winter Garden and adjoining districts in Uvalde, Medina, Maverick, Zavala, Dimmit, Frio, and Atascosa counties.)

"Ground-Water Resources of the Houston-Galveston Area, Texas," by W. N. White, Penn Livingston, and S. F. Turner, October 17, 1932.

"Ground-Water in Dimmit and Zavala Counties, Texas," by W. N. White, S. F. Turner, and W. A. Lynch, April 11, 1934.

"Summary Report on the Survey of the Underground Waters of Texas," by W. N. White, March 1935.

Organizing for Watershed Development

By T. C. FORREST, JR.
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DEVELOPMENT of watersheds on an organized basis is a new thing in Texas, but there has been so much activity in this connection in the last few years that the idea now commands the attention of engineers and, from press reports, appeals to the sound judgment of business leaders as well.

Texas is young. Its people are but three or four generations removed from the pioneer settlers of the state, and they find it difficult to divest themselves of the pioneering spirit. However, it is now apparent that they must do so. They can no longer move on to better and richer locations when droughts, floods, and soil losses deplete their holdings; they must become stable in their present surroundings.

The present generation is adjusting itself to this fact, and it has become more deeply interested in the re-

sources that are at hand. It is taking note that the rich soil is rapidly becoming depleted; that the fertile valleys contain the best soil of the state; that floods prevent the development of these valleys; that in some cases the streams have become so polluted that their valleys are not fit for human habitation.

The geography of Texas can best be described as a series of low ridges and valleys whose general direction is from northwest to southeast; and a series of plains crossing these ridges and valleys, each plain comprising topographically a step down from the higher western plains to sea level along the Gulf of Mexico. The streams have cut their way through the steps and flow directly into the Gulf. The watersheds are long and narrow. Of the eight major streams, all but the Rio Grand have their origin within the state. Lines of equal rainfall run generally north and south, the rainfall varying from 50 in. along the eastern boundary to 10 in. along the western.

Since the streams flow roughly from northwest to southeast, wide variations in rainfall, soil, and climate may exist within a single watershed. Until the depression era these natural conditions were accepted as benefits or handicaps, as the case might be, without serious consideration. Then the need for increasing income made people conscious of the importance of conservation, and common bonds of interest were formed which spread beyond the boundaries of localities and counties.

To John A. Norris, M. Am. Soc. C.E., former chairman of the State Board of Water Engineers, should perhaps go the credit for the first watershed plan in Texas. The organization of watershed districts gained considerable impetus after the passage of the Flood Control Act of 1936, and today we find six of the main watersheds organized, and one other with an organization bill before the legislature.

Some of the watersheds are not organized as a unit. The Neches has two political subdivisions, and the Colorado has three. Such situations should be corrected. Legislation has been hastily prepared and amendments are not being given proper consideration. Most of the organization bills are similar, but the soil erosion control features are each separate and distinct, even though they are patterned after a model bill prepared by the U. S. Department of Agriculture. This will constitute a handicap to logical development unless there emerges from the confusion a state-wide soil erosion control bill that will permit watershed districts to function properly.

In any comprehensive project for the development of a watershed, the farsightedness and aggressiveness of "the people" are by far the most important factors contributing to success or failure. For the moment, the people of Texas are enthusiastic over the possibilities. The activity of the Soil Erosion Service of the U. S. Department of Agriculture has caused farmers, business men, and bankers to become "soil conscious." Another factor contributing to the enthusiasm is the new flood-control program of the federal government. This policy has reenergized the flood-control advocates, added to their ranks, and promoted consolidation of effort.

Naturally, it was soon obvious that a district embracing the entire watershed of a particular stream would be the smallest unit that could properly represent an area. And so districts embracing entire watersheds, or substantial parts of them came into existence through the acts of the state legislature.

Perhaps the greatest task of a watershed district is to keep alive interest in ultimate objectives. Ten years cannot see the completion of an entire plan, and within that time a new generation will have entered the scene. Without publicity as to accomplishments and objectives, the present generation will lose interest, and without education the one to follow will lack the incentive to carry on the work. Wise will be the management of a district that recognizes this difficulty and prepares well-founded, long-range plans to overcome it.

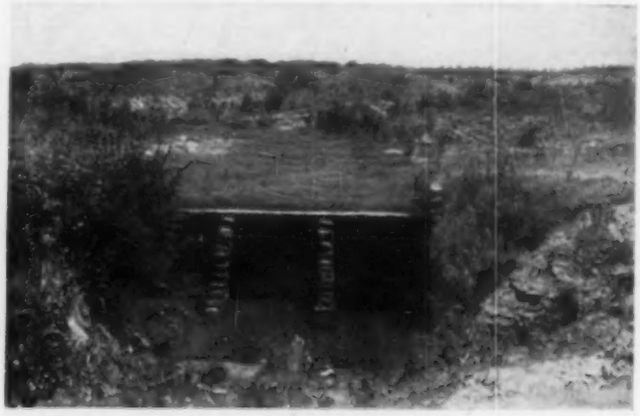
SABINE-NECHES AS AN ILLUSTRATION

It is interesting to note some objectives. The Sabine-Neches watershed program for east Texas is divided into five principal parts, with subdivisions under each. They are as follows:

Soil and water conservation: Land use survey, strip cropping, contour furrowing, terracing, rodent control, check dams, reservoirs.
Drainage and flood control: Levees, ditching, channel rectification.
Submarginal land retirement: Reforestation, grazing land.
Health: Mosquito control, pollution control.
Recreation: Parks, lakes, game preserves.

Soil and water conservation ranks first. The topography of the watershed varies from gently undulating to hilly, and the soil is a sandy loam. In the past it was heavily timbered, but lumbering has made rapid inroads on the supply. The stripping of large areas and subsequent cultivation have caused heavy losses of top soil, and gullying has progressed rapidly. The U. S. Department of Agriculture has aroused considerable interest through its work on a model terracing project covering a small watershed (as illustrated in a pair of accompanying

(*a*) CCC Boys Beginning Excavation for Control Structure in Summer of 1934 After Farm Has Been Placed Under Agreement by U. S. Soil Conservation Service



(*b*) Two Years Later—Note Growth of Bermuda Grass Back of Structure and Black Locust Trees Along Sides. In Five Years Grazing Can Be Permitted

RECLAIMING TEXAS LAND THAT HAD BEEN RENDERED USELESS BY GULLYING

illustrations) and through the activities of its CCC camps.

Water conservation is of increasing importance. The area is growing in population, and many towns are now in search of additional water supplies. Rural areas are becoming interested in providing supplies for stock on individual farms. The State Department of Agriculture is encouraging this by maintaining a service which advises on locations, types of dams, and spillway capacities. In Cherokee County several small reservoirs, ranging from 3 to 25 acres in surface area, have already been constructed. Another important need for water conservation is to supply a deficiency in the coastal belt, where large areas are planted to rice. In the early days of rice-growing, it was a simple matter to augment the supply by pumping from the rivers. However, as the acreage increased, the low-water flow became insufficient. The situation was further aggravated with the advent of navigation on the lower reaches of the Sabine and Neches rivers; the deepening of channels and the removal of bars permitted the encroachment of salt water to such an extent that many pumping plants had to be abandoned. A stabilized flow of fresh water would correct this situation.

An Estimated Flow of 35 to 45 Cu Ft per Sec Above the Fault

Low Flow Disappears in Cavernous Limestone Outcrop

SABINAL RIVER, LIKE OTHER STREAMS IN WINTER GARDEN AREA, DISAPPEARS BELOW BALCONES FAULT

OTHER PROBLEMS IN EAST TEXAS

Drainage and flood control are important in this area. The major streams are sluggish; flood waters are slow in receding, and the stagnant pools encourage mosquito breeding. The malaria fever mortality rate is rather high, and a large percentage of the people are susceptible. Channel rectification is a simple, economical way to improve this condition and to make the cultivation of the flood plains a safe undertaking.

If a program of submarginal land retirement is to succeed, there must be an incentive. Since lumber was once a great asset in the area, attempts are being made to encourage the planting of pine seedlings. The Forest Service of the U. S. Department of Agriculture is now establishing four units of which one million acres are in these watersheds. It is now known that pulp from young pine trees is excellent for the manufacture of paper. Only recently funds necessary for the establishment of a pulp mill were underwritten in one day, and studies are now being made to determine the proper location. This industry will encourage the planting of pine seedlings and will therefore return many acres to their original state.

A problem involving the health of several communities is the pollution of streams from oil-field wastes. The largest oil field in the world occupies parts of both the Sabine and Neches watersheds. Producing wells are to be found within the stream bed of the former, and at the present time there are more than 25,000 wells in this field. Refinery wastes and salt-water discharges from the wells have so polluted the Sabine that the city of Longview has had to abandon this stream as the source of its water supply and spend approximately $400,000 in developing a new supply.

Recreation is expected to play an important part in the watershed plan. Parks are now being developed, and efforts are being made to establish game preserves.

I have dwelt somewhat at length on the objectives of this Sabine-Neches program to indicate the possibilities that might be uncovered in other areas. The projects on the other watersheds will be discussed in less detail.

WATERSHEDS PRESENT INDIVIDUAL DIFFICULTIES

The Trinity watershed has three broad objectives—soil and water conservation, flood control, and pollution control. Soil conservation is of the utmost importance, for this watershed embraces the black land belt, which contains the richest soil in the state. The necessity of water conservation is likewise paramount, for the large urban areas depend solely on this river as a source of water supply. And again the territory bordering the Gulf requires additional water for the growing of rice.

The Brazos District has two broad objectives—soil and water conservation and flood control. While power is only incidental, it will probably be an economic factor in furthering the principal objectives.

The Colorado watershed is divided into three political subdivisions—Upper, Central, and Lower. The Upper District is interested in water conservation (for irrigation), soil conservation, and flood control. The Central District, a ranching area, is concerned with soil conservation, and conservation of surface water for domestic and stock uses as well as for municipal supplies. In the Lower District, soil conservation, generation of hydroelectric power, flood control, and irrigation (of rice) are all of importance.

The Guadalupe River District has three objectives—soil conservation, generation of hydroelectric power, and flood control. The latter is quite a problem because of the flashy runoff of many streams in this area and the lack of storage facilities.

In the Nueces District, flood control, conservation of water, and soil conservation all demand attention. The area has had a tremendous growth in the last decade, and Corpus Christi, its largest town, needs the assurance of more water at this writing.

The Winter Garden section, so named because of its winter production of fresh vegetables, depends upon underground water for irrigation. The water table is rapidly dropping, and pumping costs are rising at a corresponding rate. If this section is to prosper, either the water table must be brought back to an economic pumping level by means of broad irrigation of the area where the water-bearing stratum outcrops, or the ground water must be supplemented by a surface supply and a canal system.

In this area an uncommon condition augments the

usual flow losses. A fault zone traverses the watershed in a southwesterly direction. Through the transition in elevation and for a short distance along the lower level of the fault, a cavernous limestone stratum is exposed, across which the West Nueces, Nueces, Dry Frio, Hondo, Seco, and Sabinal rivers flow for a distance of three to ten miles. During periods of low flow the entire discharge of these rivers disappears in this formation. Sharp rises above the fault dwindle to mere trickles below. The slope of the stratum is so steep that economic pumping is possible for only a short distance downstream. This water has a value, if it can be salvaged. Its conservation is one of the main objectives of the district.

FINANCING BY TAX DIVERSION

How are funds to be provided for such ambitious programs? It must first be borne in mind that these watershed agencies are not permitted to raise funds by taxation. This power was specifically denied them by the legislature in the acts which created them. The main anticipated source of funds is tax diversion. Most of the districts have amendments now before the legislature asking that certain normal state taxes collected from the area be assigned to that area to carry out its program. The Brazos watershed was the first to secure this form of financing. Approximately $300,000 a year for twenty years is set aside to carry out its program. This sum can be capitalized to produce approximately $6,000,000 for immediate use.

Federal funds will be made available for flood control, and they are now being appropriated for other uses in cooperation with both the Brazos and Colorado districts. Naturally, the other districts hope to be equally fortunate. Wherever possible, the sale of hydroelectric power will constitute another source of revenue. Much is expected in the way of technical supervision from the forest and soil-erosion services of the U. S. Department of Agriculture. Finally, it is expected that the landowner will contribute with labor and materials in connection with the soil conservation and reforestation features.

Without tax diversion it is believed that these districts cannot go far with their general program. The argument presented in favor of tax diversion is that the sums expended will be returned to the state many fold in increased taxable values, and this is undoubtedly true—provided the board of directors is composed of a far-sighted, conscientious group of men, with sound business judgment.

It might not be amiss to inject a few words of caution. Watershed development is so broad in its ramifications that it should command the utmost respect of all who are interested in, or affected by it. An exhaustive analysis should be made of the effect each proposed step in the general program will have, not only on the other proposed stages of the program, but on all existing and potential characteristics of the area.

Assume that it has been definitely determined that a reservoir of a certain capacity is needed in a locality to perfect a flood-control or water-conservation plan. The studies should not cease here. How will this reservoir affect human habitation, both present and future, in the contiguous area? What will be the results to traffic and transportation? What are the mineral possibilities of the land to be submerged? These and many other angles should be thoroughly investigated and evaluated before a final determination is made. Such studies should not be handicapped by the suggestion of favored projects, by inadequate legislation, insufficient funds, or the urge for speed.

There is room for much improvement along these lines in all districts in Texas. Organizations have not been perfected, largely owing to insufficient funds and the failure to realize the vital necessity of exhaustive investigations. Legislation, in keeping with such comprehensive planning, is badly needed. Financial programs are vague and insufficient. Procedures in corrective planning and construction have not been established. Constructive efforts are particularly needed at this time to effectuate laws, policies, and procedure commensurate with the importance of watershed development.

Flood Flows of Texas Rivers

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THE principal purpose of this paper is to focus the attention of engineers and others who have to do with flood problems in Texas on the fact that over much of the state the streams are subject to enormous rates of discharge. The engineer who has to design structures to be built in the paths of floods is faced with a most difficult problem. Too often he finds that basic information, such as rainfall and stream-flow records and suitable maps, is inadequate or entirely lacking. There is, however, a large amount of data collected by various governmental agencies which is not being used to the extent it might be. This is largely due to the fact that the records are scattered through many different volumes, many of which are out of print.

To assemble in one place all existent information would be almost impossible—for example, the published records of stream flow collected by the U. S. Geological Survey in Texas are in some 50 or more volumes. But there is urgent need for revision of many of these records and for their compilation in such form as to make them readily available for the widest possible use. The expense would be fully justified. Although probably more familiar with the records of Texas streams than the average user, I found the task of compiling the data presented in this paper considerably more time-consuming than was anticipated, because of the number of volumes that had to be consulted.

As compared with the valleys of the northeastern states, those of Texas are sparsely populated and undeveloped. In general, few encroachments have been made by the works of man on the natural floodways of Texas rivers, although in many cities the floodways have been considerably reduced by buildings, bridges, and other structures. It is only a matter of time, however, when conditions along Texas streams will be the same as those along the congested channels in the northeastern states unless the occupancy of flood channels is regulated and their use restricted to such purposes as will not materially reduce their carrying capacities. The construction of river channels by factories and other structures should

Flood of June 14, 1935, near Uvalde, Shortly Before Its Crest

All That Was Left of the Two Bridges After the Flood

A NUECES RIVER FLOOD AND ITS CONSEQUENCES

not be permitted when there is plenty of room for these developments well above the highest possible floods. River banks and flood plains are generally eyesores. But could they not be made beauty spots by reserving them for parks and playgrounds? Such developments will not restrict waterway capacities, and the flooding of them will cause a minimum of damage.

With a little vision and proper planning, there is no sound reason why floods in Texas cannot be greatly reduced and much of the flood water put to beneficial use. Extensive storage of flood waters must necessarily precede any considerable industrial or agricultural expansion dependent on the use of surface water supplies.

Such storage is not incompatible with storage for beneficial use. Texas needs both stored water and flood control, and with a proper combination of reservoirs, levees, and channel improvements, a large part of the flood water that is now passing unused to the Gulf can be economically controlled.

There may be some misconception of the flood flow of Texas streams as compared with better-known rivers in other parts of the country, and for that reason it may be enlightening to make a few comparisons.

On September 10, 1921, Little River at Cameron, Tex. (drainage area 7,034 sq miles), had a discharge of 647,000 cu ft per sec as compared with the flood of 1851 on the Mississippi River at Keokuk, Iowa (drainage area 119,000 sq miles), which had a peak flow of only 360,000 cu ft per sec.

The discharge of the Colorado River (of Texas) at Austin, Tex. (drainage area 26,400 sq miles), was 481,000 cu ft per sec on June 15, 1935. The spillway for the Fort Peck Dam on the Missouri River in Montana (drainage area 57,725 sq miles) has been designed for a possible maximum flow of only 380,000 cu ft per sec, and the maximum known flood at that place had a peak discharge of but 154,000 cu ft per sec. Again, the maximum discharge of record of the Colorado River (of Colorado) at Topock, Ariz. (drainage area 174,000 sq miles), some distance below Boulder Dam, is only 174,000 cu ft per sec; and on the Tennessee River at Muscle Shoals (drainage area 30,800 sq miles) the record discharge is but 444,000 cu ft per sec. During a 20-day period in the fall of 1936, the runoff of the Colorado River of Texas at Austin, Tex., was over 3,200,000 acre-ft, or enough to considerably more than fill the Elephant Butte Reservoir—the largest artificial lake in the United States prior to the construction of Boulder Dam.

It is interesting to note that the Nueces River at Uvalde (drainage area 1,930 sq miles) had a flood, in June 1935, with a maximum discharge considerably greater than the record-breaking flood of 1936 on the Ohio at Pittsburgh, Pa., where the peak discharge was 574,000 cu ft per sec (drainage area 19,500 sq miles).

It is impressive to compare the flood discharge of the Devils River of Texas, draining an area of about 4,000 sq miles, with the Columbia River, which drains an area of over 70,000 sq miles above the Grand Coulee Dam. Devils River had a peak discharge of 597,000 cu ft per sec on September 1, 1932. The maximum discharge at Grand Coulee during the period of record (1913–1936) was 492,000 cu ft per sec.

CAUSE OF FLOODS

Excessive rainfall is the cause of floods in Texas; neither snow nor frozen ground is an important factor. The storms that produce most of the major floods are of tropical or semi-tropical origin. They enter the state either directly from the Gulf, or across the northeastern corner of Mexico. Occasionally, though rarely, severe floods are caused by tropical cyclones (low-pressure areas), that cross Mexico from the Pacific Ocean. It is seldom that storms from the north or west cause great floods; a notable exception, however, is the storm of May 1908, which crossed the country from the Pacific coast and produced the highest stages of record on the Trinity River from Dallas to Riverside. Thunderstorms, which may or may not be parts of more general storms, often produce heavy downpours over relatively small areas. Most of the flood-producing rains in the mountainous region west of the Pecos River are of the thunderstorm type; they generally occur during the summer and early fall.

Rainfall exceeding 20 in. in 24 hours is not a particularly rare occurrence in central and southeast Texas. Weather Bureau records give 23.11 in. in 24 hours at Taylor on September 9–10, 1921, that being the maximum official 24-hour rainfall for the United States; the period of most intense rainfall was from 6:45 to 9:42 p. m., September 9, when 10.50 in. was measured by a recording gage. A rain at Hearne on June 28, 1899, filled the standard U. S. Weather Bureau gage to overflowing, and the observer estimated that the total was at least 30 in. That observation was not published. During the storm of July 1–2, 1932, which centered near the head of the Guadalupe, Medina, Frio, and Llano rivers, several unofficial but apparently reliable measurements indicate more than 20 in. in 24 hours. There is also unofficial but reliable information that at least 20 in. of rain fell in a period of about 3 hours during the early morning of May 31, 1935, at the Woodward Ranch on Seco Creek, 17 miles above D'Hanis.

Such excessive rains are often referred to as cloudbursts, which seems to be literally correct. However, a cloudburst is generally considered to be rainfall at an excessive rate "over a small area, for a short period of

time, occurring as an isolated event apart from a general storm." Actually, excessive rains in Texas are generally high centers of storms covering large areas. During the 24-hour period in September 1921, when the rainfall at Taylor was 23.11 in., an area of more than 4,000 sq miles received in excess of 10 in of rainfall.

The Balcones fault zone, which forms the boundary between the coastal plains and the plateau region, crosses the state from northeast of Dallas through Waco, Austin, and San Antonio, to the Rio Grande at Del Rio. The escarpment along this fault zone is a rather prominent topographic feature from Waco to Del Rio. The rise from the plains to the plateau varies from two or three hundred feet to over a thousand feet and is rather abrupt over much of its course. This escarpment doubtless increases the rainfall to some extent, as the warm, moist air from the Gulf on striking it is forced upward more rapidly than it would otherwise be. An exaggerated idea of the effect of the escarpment may be had, however, because of the fact that whenever intense rains occur in that area terrific floods follow. This is not because the rain is greater in amount or intensity than it often is in the coastal area, but because of the steep slopes, the shallow, rocky soil, and the narrow flood plains. Hill floods are more destructive and more spectacular than floods on the plains.

Storms from the Gulf on striking the land are naturally deflected to the north and east by the prevailing west to east movement of the air. To some extent the Balcones Escarpment and the mountain ranges in Mexico may also contribute to this change of direction.

The most general path of Gulf storms is up or across the major streams rather than down the basins; thus they do not produce as great flood peaks as if their course were down the streams. However, some of the large tributaries of the main streams follow somewhat the same direction as many of the storms.

Flood-producing storms are most likely to occur from April to October. However, in recent years two very severe storms have occurred during the month of December—that of 1913, which caused record stages on the Brazos, Colorado, and Guadalupe rivers, and that of 1935, which produced record floods on Buffalo and Whiteoak bayous at Houston.

Those interested in flood-producing storms in Texas should consult *Excessive Rainfall in Texas* (Texas Reclamation Department Bulletin No. 25, by Robert L. Lowry, Jr., Assoc. M. Am. Soc. C.E.). Thirty-three major storms that occurred during the period 1891 to 1933 were studied by Mr. Lowry in much detail and the results ably presented by text, tables, and maps. Another report that contains much valuable information regarding storms in Texas is "Storm Rainfall of Eastern United States" (Miami Conservancy District, Technical Report, Part 5, 1936).

The 6-in. isohyetals for the 33 storms studied by Mr. Lowry, and for 6 storms occurring in 1935 and 1936, have been plotted to obtain a picture of the areas over which major storms are most prevalent. It appears that such storms occur most often in the coastal plains region and adjacent areas, and that but few of them reach the western part of the state.

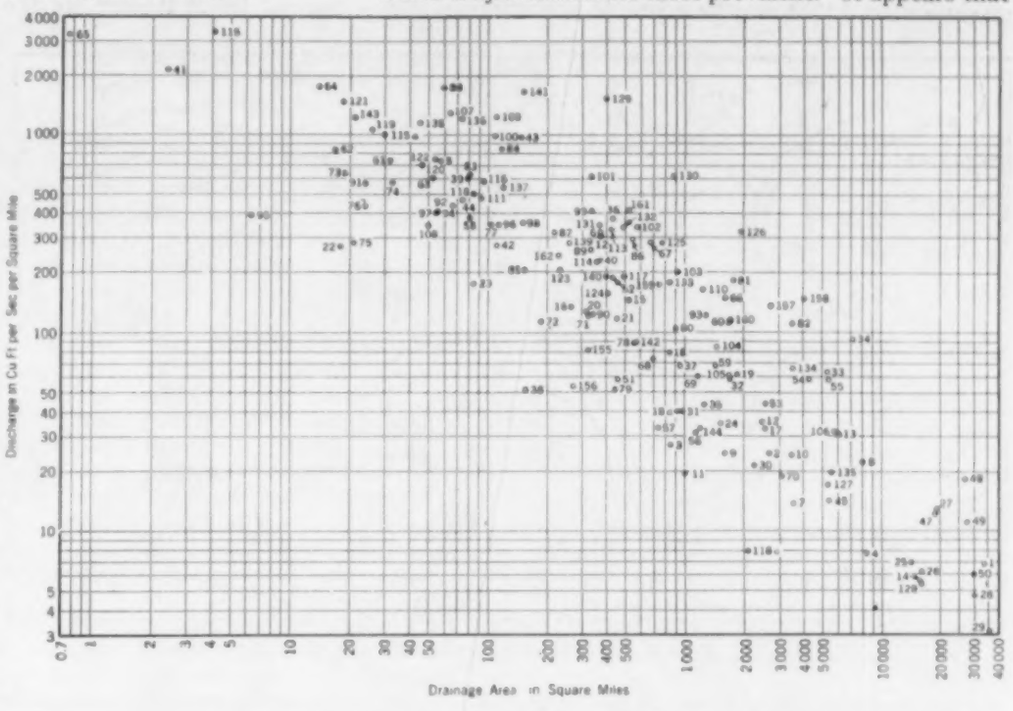

FIG. 1. MAXIMUM FLOOD DETERMINATIONS OF TEXAS STREAMS

Although the number of rainfall stations may be fairly adequate for the determination of long-time averages, it is sadly deficient for detailed engineering studies. There are areas in Texas larger than the state of Massachusetts in which there is not a single official rain gage. It is almost hopeless to attempt to make reliable comparisons between rainfall and runoff for individual storms or flood periods. An example of the inadequacy of records for rainfall runoff studies was shown by the study made immediately after the storm of June 30 to July 3, 1932, when the U. S. Geological Survey, in cooperation with the Texas Board of Water Engineers, made an exhaustive search in the field for information regarding rainfall in areas remote from official gages. This search produced information showing conclusively that the maximum rainfall was about 35 in., instead of 20.3, the maximum measured by any official gage, and that there was an area of more than 1,000 sq miles which received from 20 to 35 in. Using official records only, the average rainfall over the Guadalupe River basin above Kerrville for this storm was about 8 in.; the actual rainfall was nearly, if not fully, 20 in.

This is in no sense a criticism of the Weather Bureau. That organization has long realized the need for more rainfall records, but has been unable to establish additional stations because of lack of funds.

RECORDS OF MAXIMUM FLOODS

The maximum discharges that have occurred at 162 river measurement stations and at various miscellaneous points in Texas are shown in Fig. 1. The reference

numbers in Fig. 1 correspond to those on the map presented as Fig. 2.[1] Many of these floods obviously were not of unusual magnitude, although they are the highest for which definite information is available regarding stage or discharge at the places of measurement. They may, therefore, have little value as a measure of the maximum flood that may be expected in the future.

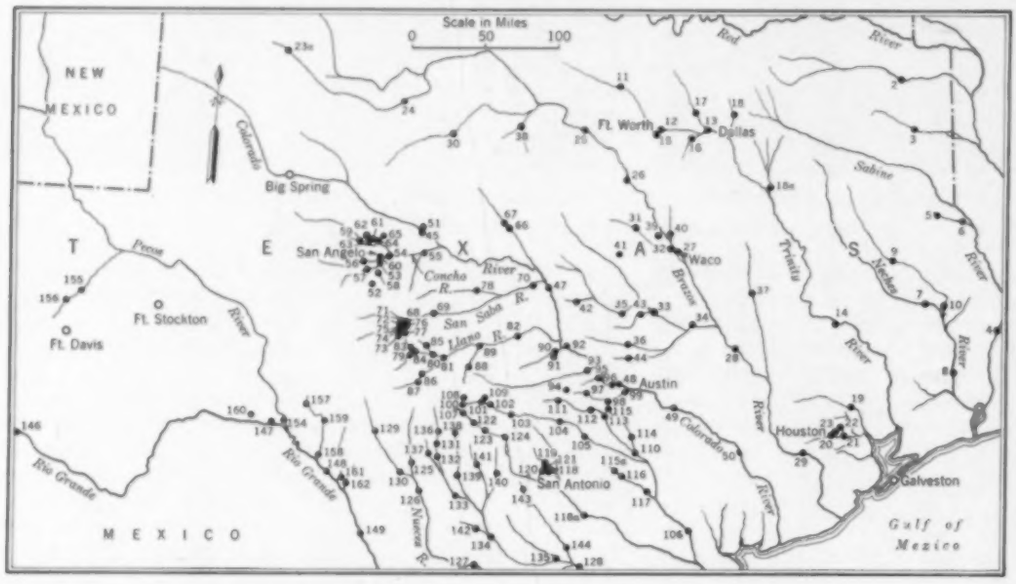

FIG. 2. LOCATION OF MEASUREMENTS SHOWN ON FIG. 1

Other floods, such as those on the East Fork of the James River at Old Knoxville (No. 88), the West Fork of the Nueces River near Brackettville (No. 129), and the Seco Creek near D'Hanis (No. 141), are clearly of unusual magnitude, perhaps approaching the absolute maximum that may be expected at those points. These floods relate to areas varying in runoff characteristics from the relatively flat coastal plains, with small stream channels obstructed by heavy growths of trees and brush and with wide overflow plains, to the steep, rocky slopes of the Edwards Plateau and the Balcones Escarpment, where the channels are larger and less obstructed. Floods in the plateau region rise and fall more rapidly and have much higher rates of discharge per unit of area than those in the coastal plains.

In any study of these measurements and comparison of one with another, cognizance should be taken of the type of drainage area above the place of measurement. For instance, the flood of December 9, 1935, on Buffalo Bayou (No. 22), with a peak discharge of 115 cu ft per sec per sq mile from an area of 458 sq miles, may come as near representing the maximum to be expected from that basin, as the flood of September 10, 1921, on the San Gabriel River near Georgetown (No. 36), with a peak flow of 371 cu ft per sec per sq mile from an area of 431 sq miles, approaches the probable maximum from the San Gabriel basin.

The physical characteristics of a river basin that affect stream flow, such as topography, soil, culture, and channel conditions, may differ greatly even in adjacent areas, and a thorough field examination of the area under consideration is of prime importance. Flood formulas that do not give full consideration to those characteristics should be used with caution.

The floods of September 1921 are discussed in detail in U. S. Geological Survey Water-Supply Paper No. 488. Those on the Rio Grande and its tributaries which occurred in September 1932 are fully described in the "Special Flood Report" of the International Boundary Commission. Reports on the major floods of 1935 and 1936 are being prepared for publication by the U. S. Geological Survey.

It is well known that the peak discharge of a flood generally decreases as the crest advances, unless augmented by sufficient inflow to maintain a constant or increasing rate. It is also well known that there are losses due to pondage, infiltration, evaporation, and so forth, but the magnitude of the flattening and the losses that sometimes take place may not be fully realized. An extreme example of reduction in flood crest and loss of water is the flood of May and June 1925 on the Nueces River. Gaging stations were maintained at Cotulla and Three Rivers, the distance between them being approximately 95 miles. At Cotulla the runoff was 293,000 acre-ft, with a peak discharge of 49,500 cu ft per sec, while below, at Three Rivers, the runoff was 160,000 acre-ft, with a peak flow of 17,600 cu ft per sec—a loss of 45 per cent in volume and a reduction in crest discharge of 64 per cent.

The record flood of September 1932 on the Rio Grande with a peak discharge of 605,000 cu ft per sec at Del Rio, flattened to 203,000 cu ft per sec on reaching Roma 4 days later. At Hidalgo, 2 days after passing Roma, the peak had been further reduced to 84,000 cu ft per sec. or only 12 per cent of that at Del Rio.

Several outstanding floods have occurred in recent years for which no information is available, either as to maximum discharge or volume of runoff. Many additional gaging stations are needed for the collection of such records. There is special need for stations on streams draining small and medium-sized areas. At the present time 84 gaging stations are being operated in Texas by the U. S. Geological Survey in cooperation with the Texas Board of Water Engineers. Of that number, all but 18 are situated on streams with drainage areas exceeding 1,000 sq miles, and only 3 are on drainage areas of less than 100 sq miles. A large part of the flood discharges shown in Fig. 1 are merely determinations of peak discharge by slope-area methods, and have but limited value in the design of water-control projects. The information needed for such purposes can be obtained only by regularly operated gaging stations. Among existing structures for the control and utilization of stream flow there are many glaring examples of uneconomical design due to lack of basic hydrologic data. The wastage on individual structures in some cases exceeds the amount now being expended annually for the collection of records for the entire state.

[1] *Editor's Note:* Mr. Ellsworth's complete paper contains an extensive table giving the exact location and date of each of these observations, together with the river stage and other pertinent information (including, in 48 cases, the total runoff in acre-feet for the flood period). The complete paper has been filed in the Engineering Societies Library, 33 West 39th St., New York, N. Y.

The New Galveston Causeway

Basic Features in Developing 2-Million Dollar Texas Structure, Now Under Way

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SUBJECT to tropical storms combined with hurricane tides, Galveston Bay is periodically in a hazardous situation as far as transportation is concerned, for across it extends the only vehicular access to a thriving city on its coastal island. Ordinary commercial needs, plus large recreational demands, have therefore required enlargement of the present two-lane roadway. In this article Mr. Bartlett explains the history of the various crossings, leading up to the present design, which adds four lanes constituting an independent causeway of great importance as a transportation as well as an engineering project. This valuable record of notable construction, now about one-third finished, was originally presented before a joint session of the Structural and Construction Division of the Society at San Antonio, Tex., on April 22, 1937. A more complete account, with ample illustrations, is on file at Society Headquarters and available for reference.

GALVESTON, with a present population of some 60,000, is situated on a low coastal island on the southwestern side of the pass and channel which serve deep water ports at Texas City and Houston as well as at Galveston. The latter city is more important than its population would indicate. First, the port at Galveston proper handles some 35 per cent of the export trade of all the Texas ports, and Texas ranks consistently next to New York in total value of exports. In the second place, the 30-mile Gulf beach at Galveston enjoys an enormous resort business, particularly for the 400,000 people in Houston, only 50 miles away.

All the railway and highway crossings of the western arm of Galveston Bay, between the island and the mainland (Fig. 1), leave the island some 5 miles from the business district, and 9 miles from the pass, and lead to Virginia Point. The net length of the crossing between shores is 1.9 miles, across shallow water. A central section, with its bottom 5 to 13 ft below mean low tide, is traversed by the Intracoastal Canal having a minimum depth of 9 ft. The roadway approaching the present causeway from the east is parallel to the shore and at an elevation of 7 to 8, rising to 12.5 on the filled approach and to 16.5 across the arched bridging. Near Virginia Point on the west, the mainland has a natural elevation of only 4 ft. Beyond, the flat prairie lowland slowly rises to 25 ft about 10 miles back from the bay. On the mainland approach the highway level is approximately 6 ft; the railways are on embankments 3 to 5 ft higher.

On September 8, 1900, Galveston was struck by a devastating tropical hurricane, which not only destroyed all the bridges to the mainland but also a large part of the city itself. With its loss of several thousand lives, this was one of the worst disasters of modern times. The first steps in rehabilitating the city and rendering it safe against a repetition of such calamity were the construction of the seawall along the ocean side and of adjacent fills, both of which operations have since been extended from time to time.

A more substantial approach crossing was finally financed as a joint endeavor of the railways, the Galveston-Houston Electric Railway, and Galveston County. This structure, built in 1911 and 1912, consisted of twenty-eight 70-ft reinforced concrete barrel arches with solid spandrels, also a 110-ft clear drawspan, or a total of 2,455 ft. of bridging. Dredged fills of 3,700 ft on the mainland end, and of 4,500 ft adjacent to the island were confined between concrete sheetpiles with concrete top wales 139 ft apart, tied across by protected steel rods. Above this construction was a 2:1 slope protected by concrete slabs and top curbing. There was vigorous protest from at least one of the railway engineers against thus blocking the greater part of the width of the Bay.

TROPICAL HURRICANES MENACE

When, in August 1915, Galveston was again visited by a tropical storm, the seawall and regrade proved effective protection against loss of life and serious property damage in the city. However, the combination of high tide and wave and current action swept away the causeway fills down to and even below original bottom, leaving the sheetpiling and cross-tie rods practically intact. The arch bridging was undamaged, notwithstanding the impact of current and waves against the considerable obstruction offered by piers and spandrels. There was a storm tide of 12 to 13 ft, with wave crests breaking across the deck. The piers had been carried down 16 ft below mean low tide and founded on untreated wood piles 30 ft long. Considerable scour occurred below the piers, presenting an immediate and serious hazard in these teredo-infested waters. Dredged filling was promptly placed to cover the exposed piling.

Following recommendations of a board composed of Lincoln Bush, chairman, A. N. Talbot, and the late George F. Swain (all of whom have been Presidents of the Society), 5,530 ft of additional arch bridging was completed in 1922. The transcript of the proceedings of this board is of signal interest, because the thorough consideration given the project and the practical views and decisions display the great engineering abilities

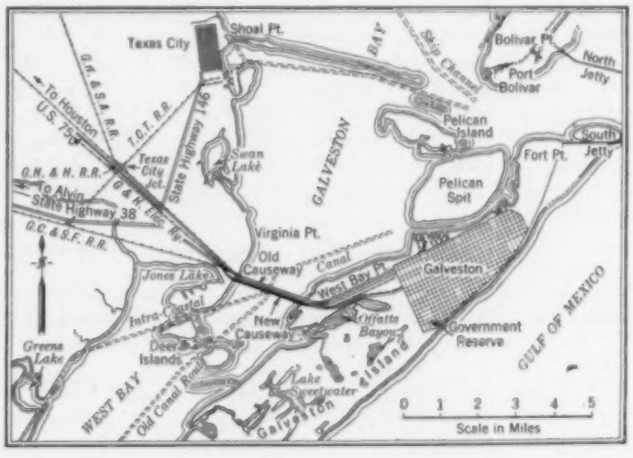
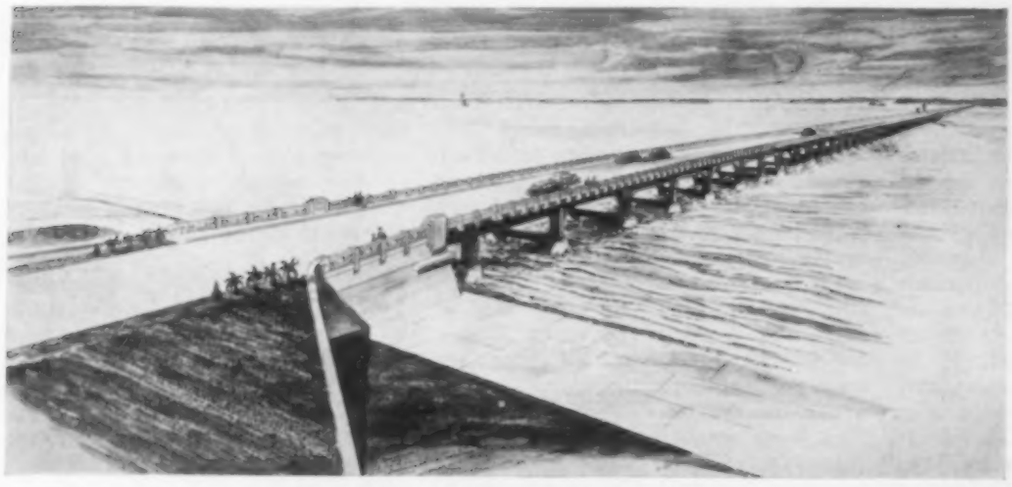


FIG. 1. LOCATION MAP—GALVESTON AND VICINITY

brought to bear on the problem of reconstruction.

The structure is subjected to severe corrosion conditions, being in and over salt water in a warm and somewhat humid climate. For this reason the steel and cast iron in the drawspan and the reinforcement in the arches, spandrels, and roadway railings of the original structure dating from 1912, as well as the fifteen-year-old extensions, were recently examined with considerable interest. As would be expected, corrosion of the truss metal has progressed to some extent, particularly on horizontal surfaces such as floor beam flanges; and castings show some evidence of corrosion. The concrete work, both of the original section and the 1918–1922 extension, is in surprisingly good condition, indicating that it was excellent engineering construction.



PERSPECTIVE VIEW OF FINISHED STRUCTURE

Primarily the damaging effect of severe cyclonic storms, when striking low coastal lands and shallow interior bays such as exist along the Texas coast, is not due to the hurricane winds, nor to the attendant waves—it is the abnormal tide height which makes the damaging waves possible Consider the whirlpool condition at the center of such a storm in the open sea. The wind from all points of the compass blows nearly toward the middle; the water level must be considerably raised. When the storm center moves over against a shelving shore, possibly backed by rising ground, then the ocean is raised still higher. The records of the more severe Texas storms indicate a still-water height of 12 to 13 ft above ordinary gulf level. The serious nature of such a phenomenon in a region where ordinary tides range from 1 to 2.5 ft above mean low tide can be readily understood, particularly when it is remembered that the surface is a seething mass of waves and drift. Another possibility of grave damage lies in the major currents incident to the sudden movements, in and out, of tremendous masses of water over the recent unconsolidated alluvial formations which comprise the entire Texas coast.

NEW CAUSEWAY DEMANDED

Galveston is now served by a number of highways including a minor one not shown in Fig. 1, reached only by ferry across the Galveston Ship Channel adjacent to the pass.

A boulevard with four traffic lanes extends from the city to the causeway. From the island end across the causeway and to a road junction 2.5 miles beyond Virginia Point, traffic on both Highways 75 and 38 is carried by two lanes for a total distance of 4 miles. For the 1.5 miles on the present causeway arches, the roadway is only 19 to 20 ft in width without any space for turnout for disabled cars or pedestrians, and the capacity is further considerably restricted by an offset at the drawspan. There is also a railway grade crossing of the main line Gulf, Colorado and Santa Fe tracks at Virginia Point with a short reversed curve. The openings of the drawspan are infrequent at present, but will be greatly increased when the Intracoastal Canal is completed to the lower coast region as immediately contemplated.

Considerable traffic congestion would naturally be expected with only two highway lanes serving a busy commercial city of 60,000 people, but when the recreational traffic to the beach is superimposed, the condition is indescribably serious. For some years the people of Galveston have urged upon the State Highway Department the importance of providing additional highway facilities across the Bay. The justice of such request has been fully recognized, especially in view of the fact that, due to the early provision of the existing structure by Galveston County and the railways, no expenditure has been made heretofore by the state on this important crossing.

In the early fall of 1935, the State Highway Department appropriated the necessary funds for building a new structure with assistance from the Public Works Administration. Engineers were accordingly engaged late in October 1935 to prepare designs. Due to the requirement of award of contracts by December 15, 1935, the time for securing of foundation borings and preparation of bid drawings was rather limited. Contract for all parts of the structure, except the drawspan superstructure and equipment, was awarded as a result of bids received December 11, 1935. This contract was on a unit price basis, permitting fuller study of the design and its refinement and detailing which were accomplished in the first quarter of 1936 along lines closely following the bid design. The work order was given to the contractors on May 11, 1936, and by April 1, 1937, 18 per cent of the work on a value basis had been completed, including parts of nearly all classifications.

The shallower parts of the bottom of the bay at the crossing are soft alluvium, at some places firm enough to support a man walking, at others with 2 or 3 ft of semi-liquid muck. The easterly three-fourths of the space occupied by bridging is generally underlaid by a bed of dense clay from 6 to 25 ft in thickness and with its top at elevation −8.0 to −15.0. Above this is a variety of sandy, mixed, or softer clay beds. Beneath it are layers of sandy clay and recurrent layers of fairly firm clay. In the westerly 2,000 ft adjoining the mainland is what appears to be an old channel with sand and alluvium to depths as low as −40 in the eastern half of this zone, lessening to −15 at the mainland shore where firmer clays or sand clays reappear. Considerable differences are sometimes encountered at points only a

few feet apart. The original half mile of concrete arch bridging did not extend to this sand hole.

GENERAL LAYOUT AND DESIGN DETERMINED

The main structure consists of continuous reinforced concrete girders with integral deck slab normally at El. 24.83, or about 8 ft higher than the old structure. The girders are continuous in sections of three spans, 201.5 ft between the through expansion joints (Fig. 2). Of the 39 sections, 16 are between the Intracoastal Canal and the island, and 23 are between the drawspan and the mainland. The drawspan and flanking spans occupy 276 ft, and adjacent to each abutment is a 30-ft span; thus the total length of bridging is 8,194.5 ft. The new causeway is parallel to the old and 535 ft southwest of it, allowing space for separation of traffic and permitting a future grade separation at a crossing of the Santa Fe Railway some 3,000 ft west of Virginia Point. Another consideration affecting the location was to separate the two structures sufficiently so that neither could represent a hazard to the other.

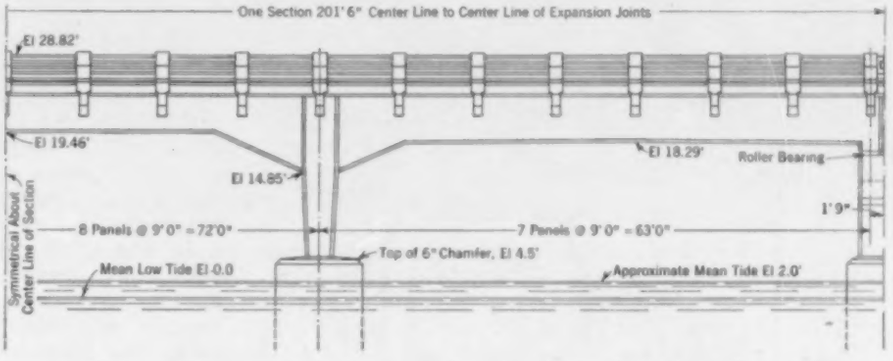

One Section 201'6" Center Line to Center Line of Expansion Joints
El 28.82'
El 19.46'
El 14.85'
El 18.29'
Roller Bearing
1'9"
Symmetrical About Center Line of Section
8 Panels @ 9'0" = 72'0"
7 Panels @ 9'0" = 63'0"
Top of 6" Chamfer, El 4.5'
Mean Low Tide El 0.0
Approximate Mean Tide El 2.0'

FIG. 2. HALF ELEVATION—ONE STANDARD SECTION OF THREE CONTINUOUS SPANS

On the mainland end the new abutment is nearly opposite the present one, with a short protected fill carrying the roadway to the shore. On the east or island end the new abutment will be nearer the shore, by approximately 200 ft, than the end of the present filled causeway which, with its seawall on the opposite (north) side, will afford some protection from storms.

The grade of the island approach fill included in present construction will be 9 ft above mean low tide, or about 2 ft higher than the present approach roadway and 6 ft lower than the seawall top along the existing parallel structure. End spans of bridging are brought down on easy vertical curves to join raised sections of the fills. The floor grade at the center of the drawspan will rise to El. 27.41, permitting an underclearance of from 15 ft at the sides to 20 ft at the center of the 105-ft waterway, thus eliminating many openings of the draw.

The new structure is designed for the 20-ton Class AA highway loading under specifications of the Texas Highway Department conforming to those of the U. S. Bureau of Public Roads. Stresses in the reinforced concrete were limited to the Joint Committee Recommendation of 1924 for 2,500-lb concrete, and 16,000-lb tensile stress in the reinforcing. The resulting high percentage of steel was desirable because its cost is relatively low on this job, whereas concrete aggregates are rather higher than usual. Saving in the volume of concrete was also desirable from the standpoint of reduced foundation loads. Percentage increases above usual working stresses were allowed for combinations of live, wind, and temperature loads. At zones of negative girder moment a portion of the girder steel is distributed near the top of the slab as additional longitudinal slab steel. Extra bars are also placed in the top of the curb in these zones.

It was considered safer to clear storm waves by placing the deck at a high level and to minimize the obstruction offered by the piers and posts, than to rely on massiveness as in the case of the existing causeway. Also, in the old causeway the use of a high-level structure would have been complicated by its combined function to include the railways.

Preliminary consideration of a reinforced concrete pile trestle, with deck clear of storm waves, was abandoned because of:

1. The length of unsupported piles above firm soil support—from 25 to 36 ft.
2. Uncertainty as to strength of a concrete pile bent of such height, particularly in resisting accumulated longitudinal components of storm thrusts acting at right angles to the lines of single piles forming each bent.
3. Uncertainty as to whether the large concrete piles required would reach satisfactory bearing—that is, piles of practicable length and of the extra large size required for the desirable 4-in. clear cover for reinforcing steel in salt water.

STABILITY OF FOUNDATIONS SUBJECT OF STUDY

The stability of the two-cylinder piers (Fig. 3) has received considerable thought, and much attention has been given to each individual cylinder by T. J. Kelly, Assoc. M. Am. Soc. C.E., supervising engineer for the State Highway Department, in order that it may carry its portion of dead and live loads without sensible differential settlement. Against longitudinal thrust components two cylinders are no more than twice as strong as one, although the two pairs of cylinders at the intermediate supports of the three-span sections are mutually stiffened in considerable degree by the deep girders and posts of the rigidly attached superstructure frames. Against transverse loads of a hurricane wind against the deck, and of swift current against posts and cylinders, the two cylinders constituting a pier are stiffened by the strut and by the rigid frame composed of the two posts with the deep connecting cross girder.

By reason of the great stiffness of the 9 or 10-ft diameter cylinder in comparison with the strut and posts, the unit action of the entire two-story frame is not relied on. An approximate analysis indicates the ability of the top frame to reduce the overturning moment on each pier base to one-half of what it would be from corresponding loads applied to the two single cylinders. The piles, with dead loads of 22 to 27 tons, depending on assumed water level and possible future paving or conduit work, would be capable of resisting considerable overturning moments if the load were removed from the piles on one side and doubled on the other. These considerations are, of course, for extreme storm load assumptions, neglecting any supporting power of the soil beneath the cylinder, skin friction, or the more important grip of the soil around the cylinder base. In order to increase the factor of safety for the piles supporting the cylinders, the caissons are carried down to penetrate at least 8 ft of the harder clay, or

12 ft of the intermediate clay soils, below the level of reasonable possibility of scour. The deepest caissons will probably go to −36, the shallowest to −18.

Consideration was given to the question of pile loads in the light of tests and of the modern viewpoint that the Engineering News Formula is not fully applicable in soils of the nature here encountered, where piles freeze on standing. This study has confirmed con-

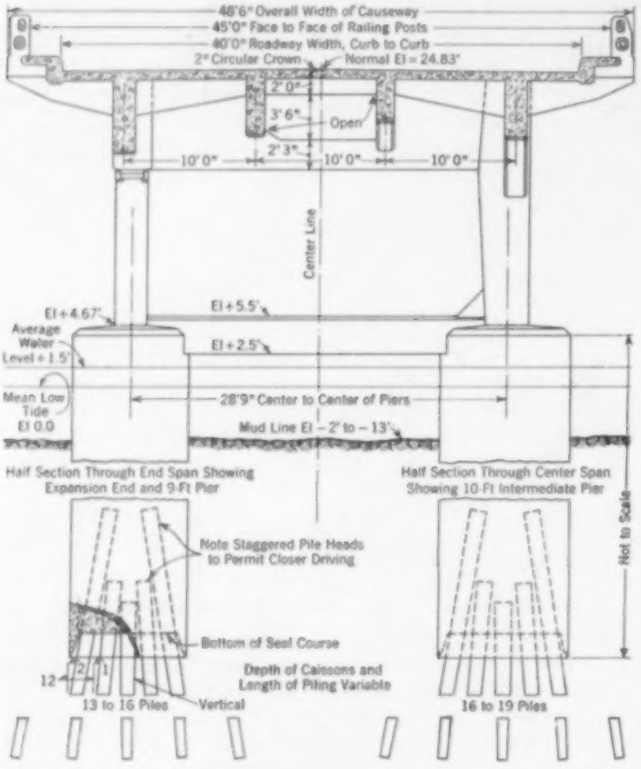


FIG. 3. CROSS SECTION OF CONCRETE DECK AND GIRDER SHOWING SUBSTRUCTURE

fidence that single piles are good for considerably greater loads than the working load by the usual steam hammer form of that formula. In determining the length of piles to use in a given cylinder, the central pile is first driven and carefully observed, frequently with a period of rest after the initial driving. The number of blows required to restart the pile and the rate of penetration thereafter are observed. It is believed that a redrive index could be developed in engineering practice, which would be a much better indication of ultimate load capacity than the customary use of the Engineering News Formula with an assumed ultimate capacity of, say, six times the value found.

As respects the load capacity of the closely spaced piles in one of the cylinders as a group, the bearing capacity has been increased by driving the outer ring of piles on approximately a 2-in. batter and the inner ring on a 1-in. batter (Fig. 3). The tips of the outer piles penetrating, say, 50 ft below a cylinder bottom at −30, are thus spread on a circle of 23-ft diameter, corresponding to a soil pressure of less than 2 tons per sq ft under the pressure bulb beneath the cylinder.

It should be stated that the concrete pier cylinders are reinforced to give moment strength to resist maximum bending strains.

Covering of all reinforcing is at least 4 in. below El. 5 and in the superstructure, 3 in. clear, outside the stirrups. The only exception is in the top of the deck where it was not considered expedient to place the steel more than 2 in. below the surface.

DETAILS RECEIVE DUE ATTENTION

The 201.5-ft deck sections have expansion bearings at both ends, reducing the movement to that for half the length. Each bearing consists of 4 cast steel rollers carried on a cast steel bed plate. The top shoe is provided with an intermediate turned bearing to permit adjustment to deflection of the adjacent span, thus preventing excessive load on the front roller. The top and bottom shoes interlock in case of any large movement, and as they are well anchored, respectively, to the girder above and the post beneath, they afford a substantial positive tie between the deck and pier longitudinally, transversely, and vertically.

Because of the likelihood of high-speed traffic across the 3-mile straightaway of the new causeway and approaches without intersecting roads or other obstruction, it was deemed advisable to place a 14-in. curb along the roadway and an unusually strong railing. The posts, which are 18 by 19 in. at the base, are 9 ft apart. The lower rail is $11\frac{1}{2}$ in. square; and the upper rail, 6 by $11\frac{1}{2}$ in.

The abutments are U-shaped with battered, counterforted face. Sidewalls extend 60 ft, spreading out to accommodate the 60-ft top width of approach fill, with long wings as required for the flat slopes used on the fills. Fills have 18:1 side slopes below El. 9 and 6:1 slopes for the portions near abutments above that level. The toes around abutments will be protected by 9-in. Wakefield sheetpiling with the outer 3-in. plank heavily creosoted. Back of abutments, the fill will be confined by a light 3-in. Wakefield membrane. A heavy riprap toe on 4:1 slope will be placed around the outside of these bulkheads with top at El. 3. Above that level to El. 6, a 10-in. shell concrete slope paving will be laid, and the remainder of the slopes sodded with Bermuda grass. The protective work and construction of the fills have been determined on the basis of funds reasonably available at the present time, rather than the most stable possible construction.

The new Galveston Causeway is being built by the Texas State Highway Department, with Gibb Gilchrist, M. Am. Soc. C.E., as state highway engineer, and Herbert Eldridge, as bridge engineer. Galveston County is furnishing all right of way. The Public Works Administration of the federal government is assisting the state in the financing of the project. Julian Montgomery, M. Am. Soc. C.E., and Uel Stephens, Assoc. M. Am. Soc. C.E., are, respectively, director and chief engineer for the PWA in Texas.

Contractors for the main structure and approaches are the Austin Bridge Company, of Dallas, Tex. Contracts for the superstructure of the drawspan have not yet been let. The total cost under the unit prices is estimated at $2,160,000. The Terrell Bartlett Engineers, of San Antonio, Tex., prepared all designs and are furnishing consulting service during construction. Waddell and Hardesty, of New York City, are consultants on the bascule drawspan. Supervision of construction is in charge of the State Highway Department, with T. J. Kelly, Assoc. M. Am. Soc. C.E., as supervising engineer, and Randall B. Alexander, as resident engineer.

The writer wishes to express his appreciation to Mr. Kelly, and the members of his staff, who have so kindly assisted with information for use in this paper. Photographs from the progress record of the project have been taken by H. P. Carothers, assistant engineer.

SCENE TYPICAL OF TEXAS AND LOUISIANA RICE FIELDS—FIRST WATERING, WHEN RICE IS FROM 6 TO 8 IN. HIGH

Irrigation of Rice in the United States

Problems Involved in the Production of a Forty-Million-Dollar Crop

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ALTHOUGH the United States produces only one-half of one per cent of the world's supply of rice, that grain is our greatest export crop with the single exception of wheat. Here Mr. Gustafson deals with the engineering problems involved in the production of rice—the duty of water, and the design of canals, levees, flumes, and pumping plants. He also gives some interesting facts about rice culture in general. This article is abstracted from the paper presented by Mr. Gustafson on April 22, 1937, before the Irrigation Division at the Spring Meeting.

RICE, a crop of which we know comparatively little in America, is probably the world's greatest. The United States raises only about 0.5 per cent of the total world production, yet with the exception of wheat it is our greatest export crop. It is the surest of great crops and is the staple food of more people on this earth than any other grain. The normal annual world production, according to the International Institute of Agriculture in Rome, is 440 billion lb of rough rice, which will yield approximately 273 billion lb of clean rice. This is equivalent to more than 100 lb for every man, woman and child on earth.

Rice growing probably began in southeastern Asia, and rice was the principal food there in the misty dawn of settled life so long ago that there is only a confused record of its origin. In the classic language of the Chinese the terms for agriculture and rice growing are synonymous, indicating that rice was the staple crop while the language was taking form, about 2,800 B.C.

INTRODUCTION IN THE UNITED STATES

About 1694 the governor of the colony that later became South Carolina obtained some seed rice from the captain of a ship in Charleston harbor. The governor, who had lived in the East and was familiar with rice culture, planted what is thought to be the first Carolina white rice. The areas suitable for rice growing in that section are the low, flat lands adjacent to rivers, the waters of which rise and fall with the ocean tides. With proper levee control, the lands were irrigated at high tide and drained at low tide.

Production was extended into other colonies, which later became the states of Georgia and North Carolina. The industry grew into one of the most important on the Atlantic seaboard and remained so until the Civil War. Although machinery could be used in cultivating the wet, marshy lands, hand labor was entirely depended upon for harvesting the crop, and the abolition of slavery was a serious blow to the industry.

Attempts to extend rice growing to higher areas in this section proved unsuccessful for two reasons—competition of other crops and unfavorable soil conditions. Even now that less than 1 per cent of the country's rice crop is grown in this section, an exceptionally high standard of quality is maintained. Carolina white rice is known far and wide for its uniform grading.

The states of Louisiana, Texas, California, and Arkansas now produce 99 per cent of all rice grown in the United States. In all, 781,000 acres were planted to rice in this country in 1933–1934, and the average yield was 46–49 bu per acre. In 1934, the last year for which the figure is available, the value of rice was about $5^1/_2$ per cent of the value of all grains produced in the United States.

It is generally assumed that rice must be grown on low, swampy lands. However, the rice fields of the United States are not in the marshes but on irrigated level land of a heavy texture, with clay subsoil through which there is little loss of water by seepage.

Sources of water for the irrigation of rice are natural streams and wells. On the lower parts of streams near the coast there is danger of pumping salt water during dry seasons. An adequate and dependable water supply is of prime importance for the growing of rice. Facilities for adequate drainage of all lands involved are also essential. The climate should be mild, with a mean temperature of about 70 F or above during the growing season. In Louisiana the irrigating period is from April 1 to September 15 for all varieties. The longest period required for any variety is approximately 100 days.

From 2 to 4 ft of water is used during the irrigating period, depending on weather and soil conditions. Ex-

RICE CROP CURING IN THE FIELD FROM TWO TO FOUR WEEKS BEFORE THRESHING

cept in cases of unusually dry weather, when it is necessary to flood the fields after planting to sprout the grain, water is first applied when the plants are from 4 to 6 in. high. Control of inundation is by contour levees located at intervals of 0.2 ft in elevation, and graded to a height of about one foot. These levees join a similar levee constructed around the outside of the field to be irrigated. The irrigation water is taken into the field at its highest point, and the flow from each contour to the one below is regulated by workmen with spades making small openings through the levees, so that while each plane is being watered there is also a certain amount passing to the one below, until all parts of the field are covered to the usual depth of from 2 to 6 in.

The contour levees are made wide, with long side slopes, and the rice is seeded, grown, and harvested across them, thereby conserving the land and permitting less room for infestation of red rice, water grass, and weeds.

It occasionally becomes advisable, when the plants are about one-fourth grown, to drain the fields and permit the soil around the roots to dry for a few days. The fields are then rewatered and a constant depth maintained until final drainage ten days before harvesting.

Heavy rainstorms sometimes overtop the contour levees and wash out openings through them, causing loss of both rain and field water, and necessitating complete rewatering from the irrigation canal.

Canal location is determined by the topography of the lands to be irrigated, the object being to transmit the water in the most economical manner from the pumping plant at the source of supply to the crest of the project. By constructing parallel levees 150 to 200 ft apart, the necessary gradient is reduced to approximately 0.5 ft per mile. Providing greater cross-sectional area does not increase the cost of construction; the only additional expense is for wider rights of way. However, it is very important to flatten the flow gradient wherever possible so as to reduce the loss of pumping head. After reaching the crest, or high ground of the project, the canals follow the ridges for distribution to the fields on each side. Checks or drops are installed to regulate the height and flow of the water.

Large canal cross sections are used because, in addition to maintaining a minimum head requirement at the pumping plant, they allow storage of water to reduce surface fluctuations when the fields are being watered. They also provide for adequate flow, since most irrigation canals in rice-growing areas soon become infested with heavy growths of grass, weeds, willows, and water lilies, which in smaller channels would materially retard the movement of the water.

The main canals and distribution laterals will continue to function more efficiently and with a negligible amount of maintenance expense if constructed by excavating from the inside. Also, the levees should be spaced to a cross-sectional dimension equal to or greater than the area determined from Kutter's formula for velocity of water in open channels, using the value of N as 0.035.

Dimensions and gradients of flumes are so designed as to permit economy in construction, operation, and maintenance. Where an irrigation canal traverses a creek or ravine to high ground beyond, several items are to be considered, such as:

1. Maximum floodway opening for the stream crossed.
2. Size and type of flume. The cheapest canal is the one with the largest flow gradient, but when due consideration is given to the added expense of maintaining a higher head from the pumping plant to the structure in order to secure a swift-flowing flume, it is obvious that there must be an intersecting point of economy between the lines of original cost and expense of operation.
3. Point of economy in length of structure and connection with the earth fills of the canal.

The cost of flumes per linear foot varies from $30 to $50, depending on type and height. The most commonly used types have a treated timber substructure with either a rectangular timber or half-circle metal carrying channel. Because the side walls can be utilized as load-carrying girders, the use of reinforced-concrete flumes has met with favor among irrigation engineers. Often in coastal areas the difference in elevation between the flood heights of streams and the irrigation waters is so small that flumes cannot be designed to function adequately in time of flood, as they become obstructed or damaged. Inverted siphons of reinforced concrete or corrugated metal are often used in crossing streams, highways, and railroads.

DUTY OF WATER IN RICE IRRIGATION

Measurements made in 1916, of water used on 18 representative rice fields in the Sacramento Valley, California, as outlined in the Berkeley Agricultural Experiment Station *Bulletin No. 279*, by Ralph D. Robertson, showed a range in the net depth of water used from 4.27 to 14.83 ft. The average depth applied to the 18 fields was 8.23 ft, and the average area served per cubic foot per second for the whole season was 47 acres, equivalent to approximately 10 gal per min per acre. The difference in use was attributed to numerous factors, the more important of which were character of soil and subsoil, preparation of land, depth to water table, and manner of handling the water.

In the University of Arkansas's Agricultural Experiment Station *Bulletin No. 261*, by B. S. Clayton, a rate of 450 gal per min for each 80 acres irrigated is recommended for all lands of the same general types as those upon which the experiments were conducted. This is equivalent to 5.6 gal per min per acre.

Prof. W. B. Gregory, of Tulane University, gives the gross duty of water in rice irrigation as 47 to 53 in., used as follows:

Transpiration	15 to 18 in.
Evaporation	14 to 17 in.
Seepage	2 in.
Loss in transit	2 in.
Waste, rain storms, etc.	14 in.
Total	47 to 53 in.

It is his recommendation that pumping-plant capacity be calculated on a basis of 12 gal per min per acre, but

some irrigation engineers in Louisiana and Texas design pumping plants and distribution systems on a basis of 8 gal per min per acre. My experience in designing rice irrigation systems is that the pumping capacity should be not less than 10 gal per min per acre of land to be irrigated. Table I gives the water pumped

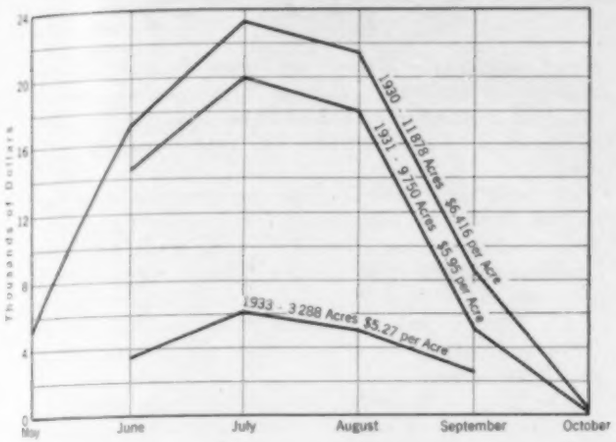

FIG. 1. COST OF ELECTRICAL ENERGY USED IN PUMPING FROM WELLS 50 TO 80 FT DEEP

On a Texas Rice Irrigation Project for 1930, 1931, and 1933

for the irrigation of 22,066 acres of rice in Texas over a period of six months. The cost of electrical energy used in pumping from wells 50 to 80 ft deep on another Texas project is given in Fig. 1.

PUMPING PLANT DESIGN

The design of pumping plants can be illustrated by a description of the pumping equipment for a 10,000- to 12,000-acre rice irrigation project in South Texas, which was electrified in the spring of 1937. The principal data are:

Average water level in river	El. 59.0 ft
Center line of pumps	El. 65.0 ft
Average water level in irrigation canal at plant	El. 98.5 ft
Suction lift (6.0-ft static plus suction pipe friction of 2.5)	8.5 ft
Discharge head (32.5-ft static plus discharge pipe friction of 5.0)	37.5 ft
Total dynamic head	46.0 ft

The layout consists of three separate units, as follows:

Unit No.	Size Pump	Efficiency, %	Capacity Gal per Min	Motor* Hp.	Rpm	Efficiency, %
1	42 in.	85.8	52,000	750	360	94.9
2	36 in.	83.5	30,000	450	450	94.3
3	30 in.	84.0	20,000	300	600	93.7

*Low-speed synchronous motors (three-phase, 60-cycle, 2,200 v)

The purpose of the variable sized units is to permit maximum flexibility and economy of operation; it can be seen that the plant as a whole is provided with seven different capacities of from 20,000 to 102,000 gal per min.

Most of the old steam plants in Texas and Louisiana have been or are being replaced by electric or diesel-powered pumping units with much higher efficiency ratings. In the vicinity of Beaumont, Tex., however, some of the original steam pumping plants continue to render satisfactory service. A centrifugal pump installed in 1899 for a 31-ft lift is still in service. Again, the Neches Canal is served by four rotary pumps with a capacity of 35,000 gal per min each, and two centrifugal pumps of 33,000 gal per min each, at a 35-ft lift. The 8-ft relift plant is equipped with two pumps of 70,000 gal per min capacity. All these pumps are operated by steam engines with the exception of one 60-in. centrifugal at the relift plant, which is driven by an electric motor.

CROP ROTATION AND RENTAL SYSTEM

More than 50 per cent of the rice lands in Texas and Louisiana are not owned by the growers. After rice has been grown on sod land for two or three years consecutively, the land is planted only about every third year, and is used for pasturing in the intervening periods. Incidentally, old rice fields prove better for grazing than prairie lands. Because of this crop rotation, it is somewhat impractical for the rice grower to own land. More often his equipment includes movable houses with farming implements.

TABLE I. WATER PUMPED FOR IRRIGATION OF 22,066 ACRES OF RICE IN WHARTON AND MATAGORDA COUNTIES, TEXAS, 1936

Month	Water Pumped	
	Acre-Feet	Inches Depth
April	7,607	4.12
May	10,921	5.91
June	21,305	11.58
July	17,907	9.73
August	18,130	9.85
September	3,903	2.13
Totals	79,773	43.32

Land rental charges range from $1 to $3 cash per acre, or one-fifth of the crop. Seed rice is furnished the grower for one-tenth of the crop, and water for one-fifth, making a total of half the crop as payment for land, seed, and water. Crop shares are delivered by the growers at the owners' warehouses, in the form of sacked rough rice.

Naturally there are many variations in these arrangements. Rice is sometimes grown by day labor on privately owned irrigation systems, where lands are leased or owned by companies also owning complete farming equipment. On the other hand, certain growers own or lease the lands and pay cash rental for irrigation water. The average seasonal cost of water is about $8 per acre.

In the Grand Prairie section of Arkansas, which contains 80 per cent of the approximately 170,000 acres of rice planted in the state, water is pumped from wells 100 to 150 ft deep. A small part of the acreage is watered from wells 700 to 900 ft in depth. Several thousand acres are also irrigated by pumping from the White River against a 50-ft lift.

Because of favorable soil conditions and an average annual rainfall of nearly 12 in. for the months of June, July, and August, the pumping requirements are only about 2.0 ft, yet the high lifts result in pumping costs of from $10 to $14 per acre. The well pits are from 18 to 24 in. in diameter, lined with steel pipe. The pumps are either electrically driven or operated by diesel engines, and consist of several stages or bowls containing impellers driven by vertical shafts from the pump heads.

THRESHING AND SACKING THE RICE CROP

Modern Uses of Maps and Methods of Surveying and Mapping

A BOOK agent was once rebuffed, it is said, by the curt statement, "We don't need a book—we've got a book." Somewhat the same situation confronts the advocates of a comprehensive mapping program. The man on the street knows that he can drop in at the next filling station for a free map that will take him wherever he wants to go; why then all this talk of lack of maps? Precisely because the available maps are adequate for his everyday use, the cry for more maps is likely to appear absurd.

It behooves the engineer, then, to present his case thoroughly, if he expects results. This is done in the first of the following articles, which merits the attention of all advocates of better mapping.

The second article describes the resurvey of 2,000,000 acres of university land in Texas. The author refers to the job as a "cadastral foxhunt" on a grand scale, and so it was—an 8-year chase over a well-nigh obliterated trail. Interesting to read, this article contains a number of valuable suggestions for land-surveyors and demonstrates the importance of their work.

A lucid description of aerotopographic mapping procedure is the feature of the concluding article. This modern method of surveying has made it possible to obtain a wealth of topographic detail and uniformly accurate contouring rapidly and at extremely low cost. The particular project under discussion is the mapping program of the Brazos River Conservation and Reclamation District.

The papers of which these articles are abstracted were presented before the Surveying and Mapping Division at the 1937 Spring Meeting of the Society, at San Antonio, Tex.

Application of Maps to Engineering Practice

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MAPPING with aerial photography, based on accurate control surveys, is a development of this century that will have historical significance equal in importance to such events as the discovery of the use of the magnetic needle. History in mapping dates back to 3800 B.C., when the Babylonians are reported to have made a cadastral survey of their entire kingdom. It was not until 1181 A.D. that we find the first authentic reference to the properties of the magnetic needle. Holman, in *Old Maps and Their Makers*, gives us the following glimpse of the status of mapping at this period in history: "About the middle of the 12th century, Roger, King of Sicily, sent men to all parts of the known world to collect geographical data. These facts he put into the hands of an Arabian named Edrisi, who compiled a world map, chiefly from the new material, and engraved it on a round table or globe of silver. The map was superior to anything that had preceded it and stimulated to some extent the study of geography. Edrisi also wrote a book on geography in which, when he had to refer to the old stories and tradition of impossible things, he generally added the phrase, 'God only knows how this is.'"

The application of maps to engineering practice may seem at first thought a trite subject for discussion. And so it would be, were it not for the present status of mapping in this country. Today we are confronted with a definite, serious lack of topographic maps; today we see, also, with this wonderful new tool of aerial photography, a reasonable possibility of the development of a definite mapping program. Recognizing the economic value of such a program, it behooves us as engineers to present the case for it thoroughly and convincingly—and in order to do so we must give careful thought to matters that among ourselves we are inclined to take for granted. We must, in short, be able to answer for the layman the question, "Of what use is a map?"

UNITED STATES HANDICAPPED BY LACK OF MAPS

The article, "No Maps in a Mapping Age," by William Bowie, M. Am. Soc. C.E., in the February 1936 issue of CIVIL ENGINEERING, gives a correct picture of the status of mapping in this country. It may further emphasize some of the points raised by Major Bowie to quote from a memorandum to the Board of Surveys and Maps, prepared by Col. Lewis H. Watkins, General Staff, Corps of Engineers, U. S. Army, under date of December 7, 1936:

"The United States, Australia, and the cold regions near the North and South poles are practically the only large areas of the world not covered by complete topographic maps including relief, drainage, vegetation, communications, boundaries, and other cultural features. About 50 per cent of the area of the United States is covered by only the new sectional aeronautical charts which are incomplete in topographic details.

"The United States is the only large industrial country not covered by accurate topographic maps.... About 25 per cent of the United States is covered by adequate topographic maps on the scale of 1:62,500 or 1:125,000. About 25 per cent additional is covered by topographic maps now out of date.

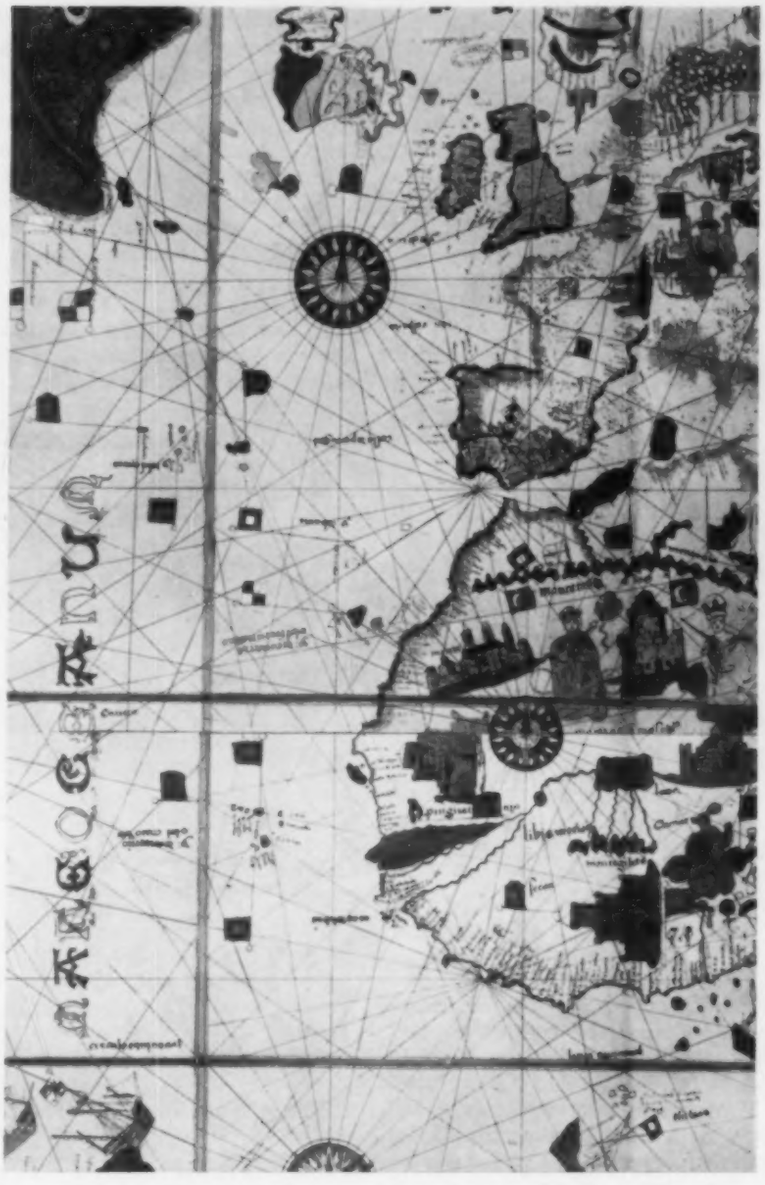
"The United States is the only large industrial country of the world which has no adequate mapping program....

"On account of the lack of complete topographic maps, the United States is handicapped in the whole of its economic development and in its national defense as compared to other nations of the world."

The memorandum concludes with a statement of the

mapping requirements for economic development of the country and for national defense.

Our present situation is accurately summed up as follows in a paper by Lt. O. S. Reading, of the U. S. Coast and Geodetic Survey ("Photogrammetry in 1936"; News Notes, Vol. II, No. 2, American Society of Photogrammetry): "Most of the overlooked opportunities, the mistakes and fortunes of the world, are due to making assumptions and generalizations from half-truths and inaccurate information. For nearly three-quarters of the United States, the best available maps are generalized compilations of a heterogeneous lot of poorly coordinated traverses, plats, reconnaissance surveys, and sketches. Very few Americans are acquainted with accurate detail large-scale maps of the type made in all the leading countries of Europe. Although most of such maps were made by expensive ground methods, and their land of comparable fertility sells for the same price as ours, these countries have found the maps excellent investments. They say they must have such maps to act intelligently and that only a country as rich as the United States could afford the waste of doing without them.... We who are working in photogrammetry in 1936 look forward to the day when any man may sit at his desk and visualize, with the aid of accurate detailed large-scale maps and aerial photographs, any part of the country in which he may be interested; to the day when he may plan his actions precisely in accordance with the basic facts about the land and move with speed and certainty instead of being compelled to wait for expensive special surveys, or muddle through with generalized half-truths on many of his maps as at present."



A GOOD MAP IN ITS DAY—JUAN DE LA COSA'S CONCEPT OF GEOGRAPHY (A.D. 1500)

Imagination Helped to Brighten Up Spots That Might Otherwise Have Remained Bare. The Original Map (of the Entire World) Was on Oxhide; a Lithographic Copy Is in the Coast and Geodetic Survey Library Collection

INTELLIGENT PLANNING REQUIRES ADEQUATE MAPS

In the following paragraphs, some of the engineering applications of maps will be briefly touched upon. It is recognized that, after the country is completely and adequately surveyed and mapped, we may find that the information will be of more value for some purpose not now known than for any of the presently obvious uses.

Perhaps the most inclusive item in the list of map uses is "planning." Certainly without good maps we can do no reliable and permanent planning on a national, regional, or even local scale. In the pamphlet, "Mapping for National Planning," published by and for the Surveying and Mapping Division of the American Society of Civil Engineers in 1935, this application of surveying and mapping is covered in a very thorough manner. The following quotation is particularly applicable to the subject: "While it cannot be said that the lack of maps is the cause of the present economic crisis, yet it is believed that if in the past there had been a complete knowledge of all our natural resources and the mapping of our country had been done, our captains of industry and officials of Government could have planned our activities in such a way as to have at least softened the blow given our nation by the depression." Our general planning of work projects could have gone forward much more rapidly, accurately, and permanently had we had complete, modern maps to use at the time when funds were made available for the relief of unemployment.

With the organization of planning boards in the various states, the policy of planning our development is rapidly taking definite shape. Planning is essentially an engineering operation, and the procedures to be followed must finally be developed by engineers. Even the first phase of planning—that is, the assembly of statistics and other data—requires the use of accurate and complete maps, and until they are available there can be no permanent progress in the development of reliable plans.

As for city planning, it has been said that only in complete topographic maps "can a safe basis be found for plans that will provide the most economical and effective layout of new streets, sewers, parks, water systems—in short for a city plan that will minimize the total

draft on the taxpayers for public works and give the maximum results for the money expended."

Our highway systems have been connected, the larger "gaps" have been bridged, and we are now able to go from any part of the country to any other part without serious delay. The next step that will undoubtedly be demanded by the public is the orderly planning of the

TOPOGRAPHIC MAPPING IN 1898 (ST. PAUL ISLAND, ALASKA)

transportation system. Highway planning surveys will provide the data to be used in developing the outlines of the plan, but when it comes to the physical planning of locations, types, and designs we will need detailed topographic maps. Otherwise, many costly mistakes will be made, and the waste will be many times the cost of the maps. It is significant that just one per cent of our present annual expenditure for highway construction would, in twelve years, pay for the entire mapping program for the United States.

IMPORTANCE OF MAPS TO AGRICULTURE

In agriculture the value of accurate maps can scarcely be estimated. Charles W. Collier, of the U. S. Soil Conservation Service, has said in "Use of Aerial Maps in Soil Conservation Studies" (Vol. II, No. 2 of News Notes, American Society of Photogrammetry): "Among the more important factors which must be determined for any given parcel of land before practical measures for soil conservation can be formulated are the type of soil, the degree and type of erosion, the degree of slope, and the present use to which the land is being put. Such information must be available in map form at large scales and great detail." He also states that "By the end of the current year [1936] the Soil Conservation Service will have contracted for aerial photographs of something over 300,000 square miles. Ultimately there will be required aerial photographs and large-scale accurate base maps of the entire area of the United States with the exception of certain mountainous and coastal plain areas."

In concluding his paper, he remarks, "It is my conviction that such aerial photographs and maps must be obtained for this whole country before we can say that programs directed towards correct land utilization, conservation of natural resources, and flood control are on a sound basis."

Irrigation and drainage development can be planned with scientific accuracy only when based on complete, detailed maps. Finally, the protection of agricultural resources from insect pests can be materially facilitated by the same means. Topography has a definite effect on temperature, wind, and other climatic factors, affecting the development and behavior of insects.

In the determination of land boundaries modern surveying finds perhaps its most important use. This application is admirably illustrated in an article by Ned H. Sayford, M. Am. Soc. C.E., on "Surveying and Mapping in the Tennessee Valley," in the December 1935 CIVIL ENGINEERING, and a more complete description of this phase of mapping is given in the article by George D. Whitmore, M. Am. Soc. C.E., on "The Use of Aerial Photographs in Cadastral Surveys," in Vol. II, No. 3 of News Notes of the American Society of Photogrammetry.

The modern systems of land boundary surveying used by Massachusetts and Hawaii are mentioned in the pamphlet on "Mapping for National Planning." New Jersey's legal procedure in adopting the plane coordinate system of the U. S. Coast and Geodetic Survey as

A PROFUSION OF ACCURATE DETAIL HAS BEEN MADE POSSIBLE BY STEREOPHOTOGRAMMETRY

The Map Shown Here Is the Work of the Brazos River Conservation and Reclamation District. The Methods Used in Its Construction Are Described in the Last Paper in This Symposium

a control for its land boundaries is described in the article on "New Jersey Adopts Plane-Coordinate System" by Philip Kissam, Assoc. M. Am. Soc. C.E., in the November 1935 issue of CIVIL ENGINEERING. However, in many states much remains to be done to improve the systems still in use. Thomas P. De Graffenried, of the New York City Bar, writing in the *National Real Estate Journal* for October 1936, said: "It was Rufus Choate, arguing a question of interstate boundary, who uttered the words which may be fittingly applied to a multitude of land descriptions which may be found in the registries of America.... 'It is as vague as the imagination of man. It is as though you should say, "Beginning at a blue jay perched upon a leafy bough in summer, and running thence 5,000 ft to a hive of bees in swarming time."'"

Let us consider briefly one example of a possibility for such improvement. The adoption of geodetic control for land boundary surveys in Texas would be a most valuable development. The plane coordinate system has already been established by the U. S. Coast and Geodetic Survey. A law providing for this change has been drafted and introduced in the legislature, but failed of passage because of the general lack of interest in this important phase of our local legal procedure.

In national defense accurate topographic maps are indispensable. There is no substitute for reliable map data in actual combat operations, and their availability can easily be a deciding factor between victory and defeat. Incidentally, at the end of the World War we were spending 24 million dollars per day. The Board of Surveys and Maps estimates the cost of completion of the mapping of this country at $117,531,000. The cost of this mapping at the above daily rate represents just five days of warfare.

MISCELLANEOUS APPLICATIONS OF MAPS

In all kinds of geological operations good maps are invaluable. It is entirely probable that the discoveries and development of additional natural resources that will follow the availability of good maps will add to our national wealth sums far in excess of the costs of the maps.

For statistical uses of every character relating to population, industry, and products, topographic maps are of great value. For example, taxation and revenue can be most equitably adjusted when good maps are available. Lieutenant Reading says, "As a result of tax equalization surveys made with the aid of aerial photographs . . . of some fourteen towns in Connecticut, the tax rate was decreased an average of 29 per cent and the grand list increased an average of 47 per cent. Such results may well mean the difference between bankruptcy and solvency to many cities in this country."

With good maps, public utilities can plan their programs for construction, distribution, and operation much more economically. The resulting savings will undoubtedly be passed on to the consuming public through the adjustment of rates for service.

Mention should also be made of the educational uses for reliable maps—a field that will be greatly expanded when such maps are available for general use. At present our public schools and colleges do not have them, and hence the students have no conception of the data they can convey. It is of interest to note that the maps used by travelers in Europe are embellished with much more detail than those available in this country, and in some instances are better than the best engineering maps of a large portion of our country. A better conception of the true character of the various parts of the country will be brought to our whole population through the use of accurate maps.

There is an enormous amount of work to be done and there are numerous problems to be solved before we can complete the mapping of the country. Money for the work must be provided by governmental agencies. Logically, the first step in field work will be the completion of the geodetic control and final adjustment of the networks. With the large expansion in aerial mapping there is danger of too much photography without proper control. The contour interval for various areas should be selected with care to insure the production of maps that will meet all the needs of the future if such procedure is possible. A policy having reference to the scheme of projection to be used for the different types of maps should be determined. For local maps the state plane coordinates should be used in all cases where applicable to familiarize engineers and surveyors with this system. For maps that require polyconic projections the plane coordinates must be shown by marginal ticks. All surveys of any extent should be tied in to the geodetic network and adequately monumented. Plane coordinate values for all monumented points must be stenciled on the monuments in the field, and their use for all kinds of reference basis must be encouraged. The development of plane coordinate control for land boundary surveys must be worked out and this method legalized by the passage of suitable state laws.

The Resurvey of University of Texas Lands

By FRANK F. FRIEND

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A GLANCE at the map of the western part of Texas (Fig. 1) will reveal twenty separate bodies of "university land," totaling approximately two million acres. The nine blocks in the most southeastern portion are the "Constitutional Grant," appropriated by the new Constitution of 1876, while the other eleven blocks are the "Legislative Grant," appropriated in 1883. These areas have just been resurveyed and their boundaries permanently marked, pursuant to a legislative act of 1929. Uncovering the elusive trail of the original surveyor proved to be a cadastral fox hunt on a grand scale—an 8-year chase that has only recently come to an end.

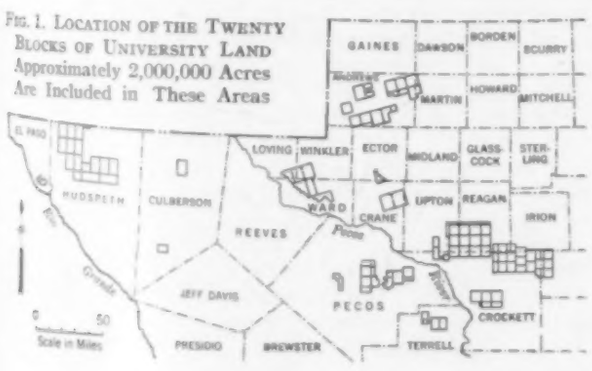

FIG. 1. LOCATION OF THE TWENTY BLOCKS OF UNIVERSITY LAND Approximately 2,000,000 Acres Are Included in These Areas

And why a resurvey? One salient fact should answer the question: Had a certain block of university land been correctly resurveyed and re-marked on the ground before oil was discovered in West Texas, not only would the new survey have remained unquestioned, but the one-eighth royalty in oil taken from a portion of that block which should have belonged to the university, though now muddled and probably lost, would have paid for this resurvey many times over.

The original surveyors were careless, and made insufficient and impermanent markings. The ravages of time have obliterated some of these, and "cadastral vandalism" has destroyed others. It seems that many surveyors, when they find an old stone mound deeply sunk beneath the soil, are not content until they have torn every rock from its place as if a pot of gold might be buried beneath it. Other surveyors, without recording their deeds, have built numerous stone mounds over the country, and these, also, after a lapse of twenty or thirty years, have seriously cluttered up the trail. To these cases of unintentional vandalism must be added a few of criminal intent—cases in which property owners have

purposely destroyed rock mounds that might be used as evidence of illegal possession.

The first step in the resurvey was to procure all pertinent legal records that could be found in the General Land Office. Photostatic copies were made of every fieldnote of university land. We also procured the records of all lands adjacent thereto. Older blocks, of course, must be located so that if there are conflicts, their extent can be ascertained. The more recent surveys, too, were of value, for they had quite naturally been tied to the older ones, and frequently provided the necessary clue for uncovering the original trail. Finally, we secured photostatic copies of the fieldnotes of all county lines, and copies of all official county maps. From all of these records, the draftsman constructed a tracing of each block to be surveyed, and blueprint copies were sent to the field.

ALL TRAVERSES WERE ENTIRELY CLEARED OF BRUSH
In Places Like This, Even the Camp Cook Wielded an Axe

The Constitutional Grant of a million acres was surveyed by R. M. Thomson in 1879. Thomson made a ground survey, and most of his work lies along the old government trails leading out through Fort Concho (now San Angelo), Forts Grierson, Lancaster, and Stockton. Most of his calls were for earth and rock mounds with but few bearings taken. Singularly, though thousands of mountain peaks were scattered over the area, only one was called for in his more than 1,500 fieldnotes.

Quite different were the fieldnotes by Dennis Corwin, which are generally conceded to be "office" or "paper" surveys. They are written in manuscript in a ruled tablet, and the heading of each fieldnote names first the block number, then the grantee, and finally, the county containing it. Corwin then begins on a corner of some older block of land (generally Texas and Pacific lands) and recites by metes and bounds the fieldnotes of the entire block, giving no date, no chainmen, no mention of authority, no certificate of legality, no magnetic declination, and no locative call. We do know that his signature is genuine.

I must digress to recount one incident in regard to the land surveyed by Corwin. All of it lay in the Texas and Pacific Reservation, and the Texas and Pacific surveyors had pronounced it worthless because it was covered by deep sand. Apparently with the same idea in mind, university authorities refused to accept some of these blocks, and they reverted to the public domain. In 1926, on one of these rejected areas, the great Wink Oil Field was brought in. The one-eighth royalty already paid individual owners from total production up to 1937 has been no less than $19,000,000. Should minerals never be found in Hudspeth County, and should the university continue to get the income from her surface leases only, it will take this body of land 727 years to pay what the oil field has paid in ten years. All this admonishes us that in land, as in man, one should look for true worth beneath the surface.

In 1886 it fell to the lot of O. W. Williams to proceed to Hudspeth County to survey the shortage of 750 sq miles caused by the rejections just mentioned. His fieldnotes, like Corwin's, were made to embrace the entire block, ranging in size from 48 to 90 sq miles each. His map, however, showed these blocks cut up into numbered sections. He called for about one dozen rock mounds, most of which we found and identified.

METHODS ADOPTED IN RESURVEY

The plan of camping on the job with appropriate transportation and equipment was followed throughout the field work. Living accommodations were very modest. Room and board were furnished by the university, the room being the big outside world, and board consisting of beans and everything contained in tin cans. Two tents were worn out from being hauled around unopened. Each member furnished his own bed roll. For bathing facilities one could choose between windmills and a bucket brigade.

Of our precision instruments, those desiring special mention are a 7-in. precise transit reading to 10 sec. and a 6-in. telescope compass. The former was used for triangulation, and the latter for accurately determining the magnetic declination for the compilation of isogonic charts. Linear measurements were made with a 50-vara steel tape, the vara being 33 1/3 in., the Texas legal linear unit of land measure. Where the roughness of the topography made triangulation necessary, portable targets with adjustable supports were provided. The targets were carbide cans (100-lb size) painted with red, white, and orange bands, while the supports consisted of pipe joints so constructed that they could be doubled for extra height.

There are two chaining methods in general practice, one of which results in cumulative, the other in compensative, error. If the chainmen face each other as the front pin is being stuck, the front chainman cannot judge that his pin is not leaning with the line being measured. Moreover, sighting down the tape, he cannot judge accurately when the tape graduations and the pins coincide. Both errors tend to be cumulative. On the other hand, our chainmen were taught to check and stick the pins while standing to one side of and facing the tape at right angles. From this position they could be sure both that the pins were vertical and that the tape graduations coincided with them.

To illustrate the accuracy of this resurvey, I cite two closures, respectively, the best and the worst of the entire job: One area of 48 sq miles (perimeter 28 miles) was closed with an error of 1 in 19,700; another area, of 204 sq miles (perimeter 68 miles), was closed with an error of 1 in 12,500. Of course, a constant error in linear measurement does not affect closures. As a check on our method of chaining, therefore, we computed the distance between two U. S. Coast and Geodetic Survey stations that were tied to our network, and compared it with the published distance. The figures were 33,420.2 varas and 33,420.4 varas, respectively.

Our triangulation work also showed high accuracy. The computed distance between two stations 20 miles from our 2-mile base line was 700.318 varas, while the distance by measurement, using the same precautions for accuracy as we did on the base line, was 700.325 varas. Although this result must be considered more

or less accidental, it helps to prove the compensative value of quadrilateral systems of triangulation.

There were many influences governing the position and shape of our traverses. However, it was our custom to begin at some known point, either within or on the boundary of a contiguous block of land, and run a line entirely around the outside of the university block, regardless of its size. This was done to facilitate the setting of permanent monuments on the outside boundaries, where the most were needed. Later, division lines were run, cutting up the block into parts of from 6 to 15 sq miles each. These partition lines were so located as to hit the most identifiable corners called for in the original fieldnotes; to follow the lines where monuments were later to be set; and to follow the course of least resistance by avoiding the rough country and thick brush. All angles turned were measured by repetition, being the mean of six readings. Each small division of the circuit was balanced separately and against the whole. Hence, errors could easily be spotted and checked.

CONFERENCES HELD WITH STATE OFFICIALS

When our network for a block was thoroughly balanced, and every possible footprint of the original surveyor had been tied in, a complete map was prepared. This map, together with a written description of each "footprint," was taken to the General Land Office for the purpose of reaching an agreement upon a construction of the area, because the commissioner, by the terms of the legislative act, must be satisfied. There, in conference, we would go over the drawing with straight-edge and triangles, seeking the most consistent solution for all questionable corners. (The commissioner was concerned only with the outside boundaries, the construction of the inside lines being left to the principal surveyor.)

When an agreement had been reached on the position of all boundary monuments that were to be set, the necessary calculations were made in the office and sent to the field in the form of work sheets. As each corner was set, the chief of party recorded on the corresponding work sheet the date, the members of the party, and the bearings, and returned the data to the office.

Our permanent markers were conical reinforced concrete posts, 7 in. in diameter at top and 12 in. at bottom, and 42 in. in length. In the top of each was anchored a 3 by 3-in. brass plate having its face divided into quadrants by two raised ribs. Before the monument was tamped in place, these quadrants were oriented and stamped to indicate the sections cornering at the point. Unless solid rock was encountered, these markers were set from 3 in. above to flush with the ground.

The method used in subdividing the various bodies of land into sections was somewhat unusual. The courses called in the original notes of the Thomson survey are without exception for the four cardinal points. Rarely, however, did we find the outside boundaries to run these true courses. The west line was usually not parallel to the east line, nor the north to the south. For the sake of symmetry and simplicity in the resurvey, we constructed a regular figure approximately one mile inside of the outside boundary, cut this up into the proper number of sections to conform to the original map, and distributed to each section its proportional share of the total shortage or excess. The east-west and north-south lines were perpendicular to each other. Then it was necessary only to slide and rotate this inside regular figure to a position which would most nearly balance the areas of the outer tier of sections. Here we nailed it down, and extended the inside lines to the boundary.

CARBIDE CANS ON PIPE SUPPORTS WERE USED FOR PORTABLE TRIANGULATION TARGETS

Every line, except the outside boundary line, we call in the resurvey east, west, north, or south, as the case may be. A notation on each fieldnote gives the correction to true geographical local course. For example: "True north is 0° 29′ 30″ to the left of the north point used in the fieldnotes of this survey." How much more valuable is this statement to a surveyor, in these days of power lines and wire fences, than a statement of magnetic declination, even though it be correctly given for the time and place by the original surveyor!

During our cadastral fox-hunt we cleared 2,779 miles of line, on which are set 15,995 hubs and 1,107 concrete monuments. The descriptive matter in the fieldnotes totals almost 2,500,000 words.

The permanent record of the work comprises 17 bound volumes filed in the Land Office of Texas. The exhibits include lithaloid prints, on linen, of the final maps and charts; a copy of the fieldnotes, prepared on a heavy grade of rag paper; balance sheets of irregular surveys; photographs of important original fieldnotes; a report of the problems of construction and their solutions as worked out in conference; and complete indexes.

Air-Mapping the Brazos River Area

By ERIC HAQUINIUS

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CHIEF OF SURVEYS, BRAZOS RIVER CONSERVATION AND RECLAMATION DISTRICT, TEMPLE, TEX.

ONE of the largest engineering undertakings in the state of Texas is the control of the Brazos River. The plan of the Brazos River Conservation and Reclamation District set up to handle this work calls for a chain of 13 major dams on the main stream and its principal tributaries (Fig. 1), subsequent construction of many smaller dams on lesser streams, and other activities such as soil conservation and reforestation.

In 1935 the District became financially able to start on its actual work, and in October of that year the mapping division was formed. Its first objective was to prepare adequate maps of the 13 reservoir areas and large-scale topographic surveys of the dam sites themselves.

As both speed and accuracy were necessary it was decided to use aerial photographs as the foundation of all this work. The pictures were taken by a private firm,

to a scale of about 1:15,000, under the standard specifications as drawn by the American Society of Photogrammetry and adopted by all federal agencies.

A scale of 1:12,000 and a contour interval of 10 ft were selected for mapping the reservoir areas. This permitted

PORTION OF AERIAL PHOTOGRAPH (REDUCED) SHOWING VERTICAL AND HORIZONTAL CONTROL

the representation of even very small tracts of land, and an accurate delineation of the flow lines. It also was considered to be more or less an all-purpose scale—that is, it was adaptable to all the various activities of the District.

The method used for making the topographic maps from the photographs had to be rapid as well as inexpensive, and for this reason the stereoscopic plotting method was adopted. The machine selected for this work is one of the newest on the market. It is considerably cheaper than the larger, older instruments, yet combines their best features; in addition, it is capable of combining a series of pictures as a unit.

ESTABLISHING HORIZONTAL AND VERTICAL CONTROL

The necessary field work consists of establishing adequate horizontal and vertical control. It must be remembered that the stereoscopic plotting machine itself is capable of bridging accurately, by aero-triangulation, fairly wide gaps in horizontal control. Thus, in places where U. S. Coast and Geodetic Survey first and second-order control and U. S. Geological Survey third-order control already exist, the field work consists simply of constructing a "gridiron," or series of traverse lines transverse to the lines of flight. These are spaced from 5 to 8 miles apart, and the ends are tied together by single traverse lines parallel to the lines of flight. The transit work is done with third-order accuracy—that is, with permissible closures of 1:7,500.

The transit parties carry the aerial pictures with them in order to select and identify their control points intelligently. The best "picture points" for horizontal control are such objects as road intersections, fence corners, corners of buildings, lone small trees or shrubs, oil derricks, and bridge abutments.

If a specially designed camera is used to take the photographs, the vertical control points can be spaced about as widely as the horizontal ones. However, the less precise camera used on the Brazos work made it necessary to run additional vertical control on the lateral margins of each flight of pictures. The lines are run to a third-order accuracy, which is specified as 0.04 times the square root of the length of the circuit in miles.

The factors controlling the selection of points or objects suitable for vertical control are to a certain extent more specific than those for horizontal control, as each point must represent the average elevation of the ground for a considerable area. An elevation on a highway or railway grade, for instance, would not be suitable if it were in a narrow cut, or on a fill or bridge considerably off the ground elevation.

One of the most important phases of the mapping is, of course, the accurate delineation of property lines. This branch of the field work is accomplished by smaller parties who also carry aerial photographs with them in the field. As they identify old corner markings of land surveys and more recent property divisions they mark them on the photographs. In the event that the actual corners are not discernible on the prints, they run a short course and distance to an object that can readily be identified, and make a notebook reference of the tie. It is safe to say that the mapping of property by this method on a scale of 1:12,000 is just as accurate as if the surveys were made by transit and tape and plotted to the same scale. Further, the property outlines become an integral part of the topography of the map; no later coordination is necessary, as might be the case if the topography and the land lines were obtained by separate surveys.

As the transit traverse and level nets are completed, and field copies of photographs showing picture points of both horizontal and verticle control have been compiled, these data are forwarded to the general office. Traverse computations are then made after determining azimuths from astronomical observations. These observations are usually made on Polaris and taken at intervals of about six miles. The work is done on the basis of closing our own loops, rather than giving weight to previously existing third-order traverse.

The first step in the office work consists of the preparation of "base sheets" showing one-minute intervals of parallels and meridians and the location of the horizontal

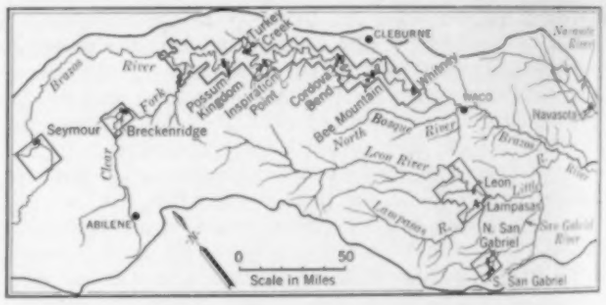


FIG. 1. PART OF BRAZOS RIVER CONSERVATION AND RECLAMATION DISTRICT
Showing Major Dams and Outlines of Areas Being Covered by Aero-Topographic Maps

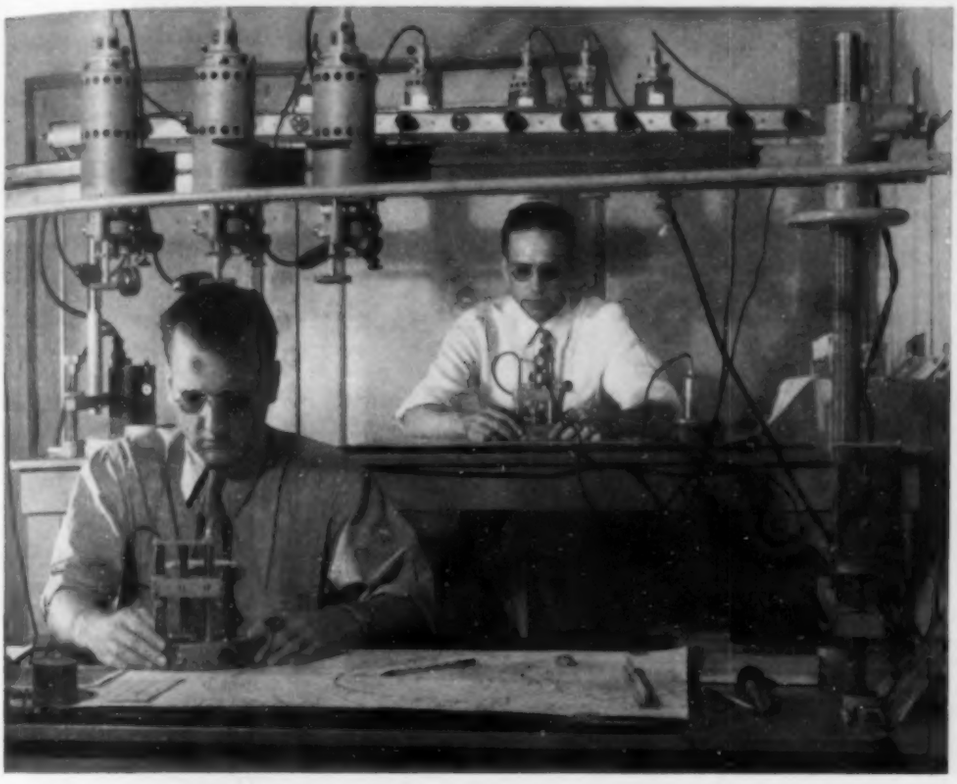
control points. These sheets are the skeleton on which the map is built up by the photogrammetrists.

DESCRIPTION OF THE MAPPING MACHINE

The mapping machine is pictured in an accompanying illustration. The steel framework is about 5½ ft long and 18 in. wide. It is supported at the four corners on leveling screws by which it can be tilted to any required position. The long horizontal bar at the top, on which the projectors are mounted, can be further adjusted by means of the handwheels on the threaded vertical supports.

Each of the vertical cylinders mounted on the horizontal bar contains (in order, from top to bottom) a projector lamp, a colored slide (red or blue), and a condenser lens. Below each cylinder is a projector arm, or bracket, containing the projection lens and a mounting for the diapositive plates. This bracket has six separate adjustments, for the correction of the six different types

of displacement which occur on photographs taken by aeroplane. Three of these adjustments correct for differences in displacement along the three dimensional axes, namely, X, Y, and Z. The other three adjustments correct for lateral tilting, forwarding tipping, and "swing," or horizontal rotation. Hence the operator can adjust the picture plate, or diapositive, to the exact position it had when the camera took the picture of the ground.



STEREOSCOPIC PLOTTING MACHINES IN OPERATION

The Projectors at the Top Reproduce a "Spatial Model" of the Topography on the Top Plate of the Movable Device in the Operator's Hand

When two adjacent pictures are properly oriented with respect to each other and projected—one in blue light and the other in red—the image of the overlapping topography appears in two colors. The operator wears spectacles fitted with corresponding colored glasses, which enable him to see the red image with one eye and the blue with the other, and thus obtain the stereoscopic effect. To the equipment thus far mentioned, is added a small sliding table that can be placed anywhere on the board. It is equipped with a horizontal, circular, white screen with a pinhole in the center through which a small light shines. This place or screen, being adjustable vertically, can be set to any desired elevation above sea-level with reference to a scale on the guidepost. Centered below and plumb in reference to the pinhole, or "luminous point," is an adjustable pencil which can be made to trace out all features of the optical image (or "spatial model") which are to be included on the map. This little table is moved around over the paper upon which the map is being plotted. As the machine is operated in the dark, the operator is equipped with a hand lamp for inspection of his work.

THE MACHINE IN OPERATION

The manipulation of the machine will be described briefly, though it will not be practical here to attempt anything more than a non-technical outline of the procedure. First, two plates of adjacent exposures are placed in adjacent projectors, and so adjusted that their centers are coincident to the optical centers of the projector lenses. Then the operator begins the series of adjustments that bring the images of the overlapped portions of the two pictures into relative coincidence. No matter how the aeroplane changed its position from one exposure to the next, within certain limits, the operator can reproduce these positions with the projectors and hold them fixed for the time it takes him to draw a map. The bundle of rays of light, which was originally reflected from the surface of the land to make the picture, has now been forced back from the picture to the "land" on a smaller scale to produce a special model, or optical relief model. This model is in such acute adjustment that only part of it is in focus on any one horizontal plane. One may pass an infinite number of such planes through the model at differing elevations, simply by raising or lowering the horizontal screen of the sliding table. In each position of the table the image is precisely in focus only for points at a common elevation. It may now be understood how contours can be traced.

Before starting to map the model, the operator must bring it to horizontal scale and horizontalize it. In bringing it to the correct scale he adjusts the X-axis motion until the images of the "picture points" that have been tied into the field traverse coincide with the same points as plotted on the polyconic projection. Then, by means of the foot-screws at the four corners of the machine, he adjusts the position of the model so that, at least, four points on the model, preferably near the corners, the "land" is brought to its correct elevation. These identified points at the corners have been tied into the third-order leveling net in the field. It is not necessary here to explain how succeeding pictures are oriented.

The operator begins to delineate the map after having one or more models in relative adjustment, to scale, and in the proper horizontal position. During this process he continuously watches the tiny luminous point in the center of the circular screen. While the sliding table is being moved, this luminous point must always be kept on the "ground." The map-making now divides itself into five main features: (1) Delineating the drainage system; (2) delineating the cultural features; (3) tracing woodland outlines; (4) tracing contours; and (5) spotting the property corners.

The luminous point is kept in continual vertical, as well as horizontal, movement in all of these features except the fourth, to contact the surface of the ground in tracing the desired outlines. In tracing out the con-

tours, the luminous point is fixed vertically and represents the actual elevation of any desired contour in feet above sea level.

The penciled maps, when completed, are routed to the drafting department for inking and coloring. These sheets are then reduced to the scale of 1:12,000 (the original plotting is done on a scale twice as large) and transferred to the final quadrangle maps. A small portion of one of these quadrangles is reproduced in the first article in this symposium.

PROPERTY LINES WERE INDICATED ACCURATELY ON PHOTOGRAPHS TAKEN TO THE FIELD
Boundaries Thus Become an Integral Part of the Topography of the Map

ADVANTAGES OF AERIAL MAPPING METHOD

It may readily be seen that the advantages of the method outlined are many. As all the mapping work is done in the office, it is possible to work regardless of weather or inaccessibility of the area involved. Topographic features can be mapped in greater detail than is possible with the most thorough ground survey, and every part of the area is covered with equal thoroughness. The contours are consistent in all parts of the map and are not subject to individual treatment as may be the case in mapping large areas in the field with a number of topographers.

In discussing the accuracy of contouring from photographs, one naturally reaches for some sort of comparison, yardstick, or standard. This is not as easy as it appears. However, comparison with the large-scale field surveys of the dam sites indicates that the small-scale contours may be within one-half contour interval accuracy.

Incidentally, much discussion has taken place recently regarding standards for maps and methods of making comparisons, and a committee has been appointed by the American Society of Photogrammetry to attempt to work out specifications for this purpose. This will be a difficult task but should receive the support of all engineers interested in mapping, and particularly those of the Surveying and Mapping Division of the American Society of Civil Engineers.

The present cost of the topographic mapping of the Brazos District is about $44 per sq mile. This includes aerial photographs, horizontal and vertical control, stereoscopic plotting, drafting, editing, and all technical overhead except the general overhead of the Brazos District itself. In order to do the equivalent work in the field by older methods, as by plane table, it would be necessary to spend from three to five times as much per square mile. Moreover, the economy in time is an additional factor in favor of the photographic method.

With a nine-projector machine equipped with two bars, and working with three shifts, the production is fairly consistent at 100 sq miles per month. The best a plane-table party can do in the same country and on the same scale and contour interval is between 6 and 8 sq miles per month, as found by actual experience in the Brazos District.

In addition to the mapping work thus far described, the Brazos District also makes topographic surveys of the dam site locations themselves and their immediate vicinity. These maps are made on a scale of 200 ft to the inch with a 2-ft contour interval. In executing this work, the area involved is gridded with vertical and horizontal control lines spaced from 200 to 500 ft apart, depending upon the vegetative cover of the country. Hubs are set on these lines every 100 ft, having a fixed position and elevation to be used for controlling the drawing of the contours. The topography is taken by plane table and telescopic alidade. It can readily be seen that control as closely spaced as this assures work of high accuracy.

The mapping and surveying activities of the District are at present limited to the reservoir areas themselves, but they will be extended to other parts of the watershed as the engineering activities so warrant. It is intended that all the mapping undertaken within the District will be done on one standard and one basis, and that it will fit in with and meet the standards of the various federal and state mapping agencies. Duplication will be avoided as far as possible, and the maps made will be adequate not only for the District itself but for all the people and organizations within the state who may have occasion to use them.

Proper recognition is due, for the adoption of these modern methods and standards, to the far-sightedness and broadmindedness of the board of directors of the District and its officers. It speaks highly for its members that they are ready to accept new and advanced methods.

Measurement of Irrigation Water

Precise Determination of Quantities Used Helps to Reduce Waste

By H. H. KIDDER

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IRRIGATION ENGINEER, DESIGNER, AND CONTRACTOR, SAN JUAN, TEX.

THE reduction of water waste that has followed the installation of accurate metering devices on a number of irrigation projects is a cogent argument in favor of taking similar steps elsewhere. In the present paper, Mr. Kidder describes various types of meters available for canals and closed conduits, and emphasizes the importance of extending their use. The paper from which this article was abstracted was originally presented on April 22, 1937, at a technical session of the Irrigation Division at the Society's Spring Meeting in San Antonio, Tex.

IRRIGATION engineers and managers are finding it increasingly important to measure carefully the water supplied to users. Reliable measurements are necessary at points of delivery to provide a correct basis for charges, and to furnish an incentive for the buyers to make the best possible use of the water received. Even in sections where water is now measured by weirs, submerged orifices, and miner's inch boxes, the additional refinements in measurement made possible by the mechanical measuring device are attracting attention.

It is true that up to the present time relatively few irrigation systems have installed such devices, but this has been due perhaps not so much to the cost of installation as to lack of information, and to the reluctance of farmers to change their habits.

Measurement of irrigation water is not in itself a new idea. The simpler measuring devices, such as the weir,

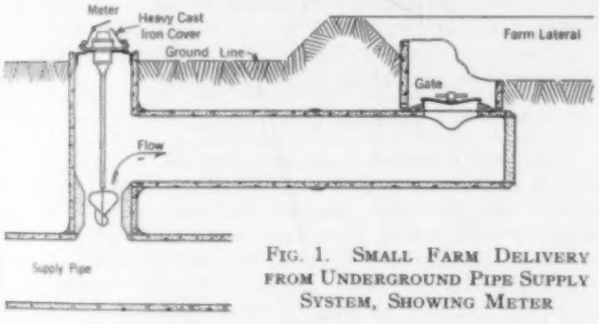

FIG. 1. SMALL FARM DELIVERY FROM UNDERGROUND PIPE SUPPLY SYSTEM, SHOWING METER

have been used for many years and are still employed where water is plentiful and there is sufficient slope to the ground.

EARLY IRRIGATION WATER BROUGHT TO THIS COUNTRY FROM AUSTRALIA

About 35 years ago or more, engineers began to work out practical mechanical means of registering and recording the flow of water. One of the first really successful mechanical measuring devices was introduced into this country from Australia. In its simplest form, it consisted of a four-bladed fan fastened at the lower end of a vertical shaft, which transmitted the revolutions of the fan to a register head at the top. This mechanism was suspended from a bracket over an orifice plate placed below the canal bed, and built into the downstream part of a box divided into two parts by a baffle wall open at the bottom and extending above the water surface. The water passed downward in the upstream side of the box and up through the orifice, imparting a rotary motion to the fan. The mechanism in the register head was geared to give a continuous record of the quantity of water passed, in units of acre-feet, acre-inches, or cubic-feet. From reports, this meter did very well. The most serious objections to its general use were its comparatively high cost and the possibility of obstruction by weeds, debris, or silt.

About 1903 Hill made a number of improvements in this meter. He thickened the hub of the fan into a hollow vertical cylinder, on which the sharply pitched vanes were placed. The purpose of the hollow hub was to give buoyancy and reduce the weight on the suspended shaft to produce greater sensitivity, especially for lower flows. The orifice was thickened so that it became in reality a short tube.

This meter was subject to the same objections as its predecessor—comparatively high cost and possibility of fouling. For some reason, no special efforts were made to market it. It was tried out by the California Experiment Station and the U. S. Reclamation Service, and possibly by others.

About 1920, a California company came on the market with another meter of the same general type. It consisted of a thin-bladed impeller on a small vertical shaft or spindle, suspended in the center of a short vertical tube set below the level of the bottom of the canal so that the throat section is always submerged. To improve its hydraulic properties, the inlet to the throat section was funnel-shaped, and had vertical vanes or diffusers above it. The impeller was a three-bladed screw. This meter was very popular, and enjoyed a large sale and use. The most serious objections to it were its cost and the ease with which it could be tampered with.

Later another California firm developed a register for the submerged orifice for small deliveries. Its operation was based on the fact that the flow through a small by-pass tube from the upper to the lower side of a submerged orifice is directly proportional to the flow through the orifice. The meter consisted of a small vertical impulse turbine, set in a by-passed stream and geared to a registering device. Adequate screens kept weeds and debris from fouling the turbine. This meter enjoyed quite a little popularity. The chief objections to it were the comparatively high cost and the work of installing the structures.

SOME OF THE NEWER MEASURING DEVICES

At present a Texas company is making a meter more or less along the lines of those first described. It consists of a thin, three-bladed impeller, suspended in the center of a short throat section, and built into a length of concrete pipe, usually of the same size as the line into which it connects. It is made to work under any pressure, from submergence to the full working head of the pipe line. It is provided with a meter box, the cover of which can be locked down to prevent tampering. This

AN IRRIGATED FIELD, ILLUSTRATING GOOD CONTROL OF WATER WHERE MEASUREMENT IS PRACTICED

meter is made in both horizontal and vertical flow types. It is fairly popular, though not much effort has been made to sell it during the depression.

Another measuring device (which unfortunately came on the market just at the beginning of the depression) was a modified venturi tube, built of concrete and equipped with a clock-driven integrator and recording system. This meter had the advantage of being free from fouling by weeds and silt, and was very accurate of measurement. However, it had the grave disadvantages of high cost, and the necessity of winding and maintaining its spring-driven clock.

Ralph Parshall, Assoc. M. Am. Soc. C.E., director of the Colorado Experiment Station, has developed a measuring flume employing the venturi principle and the hydraulic jump. Its main use is on the larger canals and streams. It is accurate over a large range of flow conditions, is free from fouling, and operates satisfactorily on a very slight loss of head. It is usually fitted with a mechanical recorder. The Parshall flume is enjoying a wide popularity, especially where the water is heavy with silt.

TABLE I. TYPICAL LOWER RIO GRANDE VALLEY IRRIGATION DISTRICTS*

Illustrating the Conservation of Water Due to Metering

DISTRICT	SAN JUAN	MERCEDES	ENGLEMAN GARDENS	ADAMS GARDENS
Acreage	55,000	67,000	6,000	5,000
Percentage of distribution system lined	28	22	100	100
Acre-feet of water pumped per acre per irrigation	1.35	1.52	....	0.26
Estimated distribution of pumped water:				
Transmission loss	0.40	0.62	...	0.02
Applied to land	0.95	0.90	0.25	0.24
Beneficial use	0.25	0.25	0.25	0.24
Wasted†	0.70	0.65	neg.	neg.
Percentage of users metered	0	60	100	100

* Lands are sandy loam, very flat; no natural drainage.
† That is, returned to ground-water table.
‡ Average for all users. Waste for metered users, 0.15.

The rating flume and current meter have been employed for years and are still in use. The accuracy of the measurements depends on the hydrographer's skill and on the frequency of observation. The use of the gage-height recorder is an improvement, but whether the rating flume is so equipped or not, the cost of measurements is high and the results not particularly good, especially on the smaller deliveries.

The meters now available are nearly all reliable, and almost trouble-proof. Equally important, they are almost tamper-proof when fitted with substantial covers that can be locked in place. The modern meters work very well with concrete pipe systems (Fig. 1). On canals, lined or otherwise, where the water carries weeds and floating debris, screens are necessary. Silt and changing conditions of pressure head do not affect their working.

CAREFUL MEASUREMENT OF WATER AIDS GREATLY IN REDUCING WASTE

In the more highly developed irrigation districts, and in localities where water is carried through sandy and porous soils, enormous sums have been expended to line the canals and to place the distributing system in underground pipe lines. Some districts are doing this work now, and others are planning to do it as soon as they can finance it. However, with the best of linings, only about 30 per cent of the present "loss" of water can be prevented. The remaining 70 per cent of the loss occurs beyond the users' gates, and is due primarily to misapplication by the users themselves. That good meters are a great help in reducing such loss is well illustrated by Table I.

On the modern pressure type of pipe distribution system, the meter permits the user to draw water whenever he wants it, and in amounts to suit his needs at the time, with full assurance that the company will receive credit for the amount of water delivered. Thus, the modern irrigation system approaches the city water system for convenience of delivery of water to users. With automatic gates at the heads of the pipe lines to maintain constant pressures, still greater convenience is obtained without increasing costs disproportionately.

AVERAGE COST OF METERS

The cost of meters is an item that must be considered, for it does cost money to buy, install, and maintain them. In the past, they were used only where the scarcity and value of water demanded close control. Now, in the more highly developed sections, they are considered as necessary as the water-tight metal gates and pipe delivery outlets. Under average conditions the cost of a good meter, installed, is about $50. Operation and maintenance costs are low; one man with a light truck or car can care for and read about 500 installations.

One of the things that retards the adoption of the measured system of delivery of water is the reluctance of farmers to change their habits. They are afraid it will cost them more, or make them control their irrigations more closely. And so it may. But in most cases, it works out for the best interests of the community.

If meters are necessary for the successful operation of city water works, how much more necessary are they in irrigation systems, where the quantities of water involved are so much greater and the consequences of waste so much more serious.

In Texas, the State Board of Water Engineers requests that meters be installed on the irrigation systems of the state, especially when plans and specifications are presented for its approval, and requests that the costs of such installation be included in the estimates. The meter gives the user the opportunity and incentive to conserve the water received. When this is done, the problems of scarcity, increasing pumping costs, rising ground-water table, and drainage are largely solved.

OUR READERS SAY—

In Comment on Papers, Society Affairs, and Related Professional Interests

Zoning for Highway Protection

TO THE EDITOR: In discussing the article on "Rural Zoning and Highway Improvement," by Laurance J. Carmalt, M. Am. Soc. C.E., in the March issue, I wish to use the term, "highway protection" instead of "highway improvement." Zoning is regulatory or restrictive rather than constructive, and the most that can be expected from it, as it is now applied, is that it will keep things from getting much worse. It has little or no effect on "improving" conditions, whether they are those of the roadside or an urban area.

It seems to me that the problem of safeguarding our major highways goes much deeper than Mr. Carmalt appears to indicate. Basic to whatever can be accomplished through zoning, and even to the successful operation of zoning within its own limited scope, are many other questions, including those of highway design and of the widths of highway rights of way and their conditions of purchase. Although Mr. Carmalt concedes that little or nothing can be done to protect major highways in built-up or partially built-up sections, he maintains that the zoning of highways in the open country should be easy. I am not so optimistic as to the relative ease with which the latter may be done. Where traffic is heavy enough to invite a considerable number of commercial roadside establishments or billboards, roadside frontage is virtually worthless for anything except farming and commercial uses. But the farmer feels he cannot afford to sacrifice for the public good either the fancied or actual revenue to be derived from the free use of his land. Furthermore, where highway zoning is established and administered by rural municipalities, both these functions are likely to be in the hands of farmers or others sympathetic to farmers.

I do not mean to suggest that highway zoning in rural areas is hopeless, but rather that we should not delude ourselves into thinking it will be easy. However, in zoning it will be found that by means of proper highway design, by the purchase of sufficiently wide rights of way, and by special agreements in land-purchase contracts, land usage can be revised or even changed entirely. By such means, and to a considerable extent, undesirable use of highway frontage can be made not only illogical but improbable. An extreme instance of this kind of highway is the so-called "freeway," mentioned by Mr. Carmalt as having no special need for zoning protection. As in the case of the railroad, the owners of abutting lands have no right of access upon the right of way of the freeway, except when and where specifically provided. Freeways are thus protected against much exploitation. But, because of their greater cost, it is probable that for many years to come, freeways will represent but a small proportion of major-highway mileage.

There are, however, many ways of approaching the freeway principle, and all of them are helpful in the effective zoning of highway frontage. For instance, highways may be of triple-roadway design, with the central single or divided speedway paralleled on either side by frontage access roads. By thus removing frontage from the speedway or heavy-duty road and giving opportunity for protective planting, the frontage becomes relatively more valuable for residential purposes. It is obvious, however, that such a highway is justified only in urban or potentially urban areas.

In strictly rural areas where the parallel "access" roads are not needed, consideration might be given to limitation of frontage uses through agreements in land-purchase contracts. Although this expedient would be simplest in connection with the acquisition of new rights of way, the same principle might be applied to existing highway frontage in undeveloped territory.

In my opinion, zoning for the highways most in need of protection, probably will have to be bolstered by such devices as those mentioned above if we are to accomplish in any large degree our ambitions for sightly and efficient highways.

Esthetic values in highways are not the only ones to be accomplished through highway protection. It must be remembered that premature obsolescence of roads is due chiefly to inadequate right-of-way widths, faulty original design, and failure to regulate and limit the location, design, and number of public, semi-public, and private points of access upon main roadways.

RUSSELL VAN NEST BLACK, M. Am. Soc. C.E.
Planning Consultant

New Hope, Pa.
June 5, 1937

Applications of Rural Zoning

TO THE EDITOR: It is a satisfaction to read the carefully organized paper on "Rural Zoning and Highway Improvement" by Laurance J. Carmalt, M. Am. Soc. C.E., in the March issue, as this topic has induced much loose thinking.

Rural zoning does not constitute an adjunct to highway improvement. It is not in the same category with highway markers or roadside planting. It is much more fundamental. When rural zoning is once established, it becomes a controlling element underlying all phases of highway improvement. Highway planning and development may be said to rest upon three groups of factors: (1) The situation at intermediate and terminal points—that is, the size and character of the cities and districts touched by the highways; (2) surface and subsurface conditions along the route; and (3) use of the land along the route. Rural zoning affects all three groups of factors to a greater or lesser degree, and it controls the third group.

In a territory such as the northern half of the state of Wisconsin —an area of perhaps 30,000 sq miles, all zoned—zoning plays a large part in the following phases of highway improvement: Determination as to whether a highway shall be built, or improved, relocated, or abandoned; determination of the route; determination of the type of road; determination of cross section; and determination of uses of land along the highway.

The value of zoning is illustrated in the case of a certain sparsely settled district, which is now zoned for forest and recreation uses. Aided by various measures, the settlers are moving out. Before the service highway is paved, it can well be relocated to form a better state highway route and to make accessible some beautiful country. At the same time, it is restricted by zoning to assure a roadside fairly free from billboards and other defacing structures.

In another county, before zoning was established, a certain two miles of a main radial highway seemed to require either a 300-ft right of way to protect its roadside, or a combination of through lanes and local service roadway lanes. In either case a long conflict might have been expected between the public interest in the use of the highway and the private uses of abutting land. Zoning established the permitted uses along this highway, and the problems of right of way, of cross section, and of roadside were immediately clarified and simplified. Most of the basic conflicts are thereby resolved.

Wisconsin has pioneered in rural zoning, as it has in so many forward-looking measures. In Milwaukee County, Charles B. Whitnall and others began this work ten years ago. Now, twenty-four Wisconsin counties have adopted rural zoning ordinances, and several additional counties are preparing zoning plans. The ordinances are being strengthened, and new features introduced. Notable among the latter is authority to zone the banks of streams to prohibit building and thus avoid flood damage and, at the same time, conserve these lands for open uses. Another interesting feature is the establishment of forest districts in thickly settled counties in the southern part of the state. In fact, the development of 25,000 miles of highways in Wisconsin is now influenced and benefited by rural zoning.

JACOB L. CRANE, JR., M. Am. Soc. C.E.
Consulting Engineer

Chicago, Ill.
May 24, 1937

Use of Artificial Vibration in Bridge Structures

DEAR SIR: The interesting article by Rudolph K. Bernhard on "Artificial Vibration—A New Method of Dynamic Research," in the April issue of CIVIL ENGINEERING, will be welcomed by engineers who are studying the dynamic properties of structures.

The use of this method on bridges would be restricted to finding the natural frequency or resonance period due to the dead load of the bridge, or to a stationary live load plus the dead load.

In railway bridges of short span the live load is large in proportion to the dead load, and the loaded frequency of the bridge varies considerably from the dead load frequency. The loaded frequency is also changing due to the variation of the live load on the span. There are two conditions of resonance: (1) With the locomotive springs locked, in which case the entire mass of the locomotive affects the natural frequency, and (2) with the locomotive springs unlocked, in which case the "sprung weight" of the locomotive is oscillating and this weight is not considered as part of the mass on the bridge. Consequently, the natural frequency will be higher because of the smaller effective weight on the bridge.

This was brought out clearly in studies and field tests by J. B. Hunley, engineer of bridges and structures of the Big Four Railway, in *American Railway Engineers' Association Bulletin No. 380*. In Fig. 9 (page 40 of this article) he shows the effect of the "sprung" and "unsprung" weights as they affect the natural frequency and the "dynamic magnifier." This latter term is the ratio of the amplitude of the magnified oscillations, due to resonance or near resonance, to the deflection of the span caused by the hammer blow when considered as acting statically at the center of the span. It is analogous to the author's term "dynamic amplifying factor."

In long-span railway bridges, where the live load is smaller in proportion to the dead load, the frequency will not vary greatly during the passage of the locomotive, and there may be only one point of resonance—that is, the locomotive springs will remain locked.

This, in general, holds true for highway bridges. Here the live load is small in proportion to the dead load, and the frequency does not vary greatly during the passage of the load. In such cases the author's apparatus would be invaluable in determining the resonance period and the "dynamic amplifying factor" for various forced vibrations, which are caused by the "sprung" weight of the truck vibrating on its springs. If the "sprung" weights of the trucks, together with their frequencies and amplitudes, were known, it would then be possible to make an intelligent study of the highway bridge impact problem.

The Seismology Division of the U. S. Coast and Geodetic Survey has for some time, used an oscillator to induce artificial vibration in bridges and buildings. The resonance periods are determined by means of a seismometer.

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San Francisco, Calif.
June 6, 1937

Some Railroad Oddities

DEAR SIR: When I was engaged in valuation work, I discovered that, to encourage settlement, the state of Texas had offered to give to railroads constructing in the state, a grant of land. For standard-gage roads, this was to consist of sixteen sections (640 acres each) for each mile of railroad built, and for narrow-gage roads, of twelve sections. But there was to be no grant for "prismoidal roads." I could not discover what a prismoidal road was, nor could I find anyone who had seen one. One man said he thought it had a base shaped like a triangle.

A few years ago the manager of the oil refinery at Camden, Ark., sent me the accompanying photograph of the "Peg-Leg" Railroad. This railroad was built about 1880, and ran from Bradford, Pa., to the oil fields. It had one rail, set on a timber stringer which was carried on a post or pile.

It was expected that the first engine would keep its balance; but it didn't, as shown in one of the photographs. A second engine, with two boilers, was then built. This seems to have been more successful. The photograph of this engine also gives an idea of the substructure. I understand that this railroad was operated for a number of years.

Monorail roads in different shapes have been in existence for some time, and examples are given in the encyclopedia, *Americana*. One such railroad, an invention of M. Charles Lartigue, has been in practical operation for many years in Djibuti, Africa; it is kept vertical by attachment to a laterally placed horse. There are others—some balanced by an overhead rail supported by bents, and others suspended from overhead in various ways.

Several years ago I read of a single-rail railroad in the north of Ireland, which ran from the town of Portrush to the Giants Causeway, carrying visitors to that remarkable scene. It was held vertical by a gyroscope, and any bridge it needed was probably supplied by a wire cable, the wheels of the car being grooved.

I might mention here, as a sort of freak railway, the Beach Pneumatic Railway, which I visited in 1869. It extended about one block under Broadway in New York City—at Barclay Street, I think. It was built for exhibition, as the company desired a franchise and the city, at that time, was adverse to having any street car on the street. The tunnel was to be very carefully and smoothly built, as the motive power was to be a current of air behind the car.

C. D. PURDON, M. Am. Soc. C.E.
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St. Louis, Mo.
June 1, 1937

The Single-Boiler Locomotive That Failed to Keep Its Balance

This Double-Boiler Engine Operated Successfully

THE "PEG-LEG" RAILROAD, BUILT FROM BRADFORD, PA., TO THE PENNSYLVANIA OIL FIELDS ABOUT 1880

What the Power Division Has Done

TO THE EDITOR: In preparing the "Survey of the Power Division," which appeared in the March issue, Lynne J. Bevan, M. Am. Soc. C.E., has performed a real service for the engineering profession, for it is an excellent, concise, and accurate review of the formation and subsequent activities of this Division of the Society. The papers presented since the organization of the Division constitute a liberal education in the power field.

Although only three Division committees have been created, the subjects assigned for study are important, and the final reports submitted constitute an epitome of the knowledge extant on these subjects. I should like to call attention to some of these reports. The committee's report on "Ice as Affecting Power Plants" (TRANSACTIONS, Vol. 95, page 1134) is a brief but valuable thesis on this subject that has undoubtedly done much to insure greater continuity of power-plant operation during freezing temperatures. Eight years elapsed between the appointment of the committee and the publication of its final report.

The symposium on water hammer, presented at the Annual Convention of the Society in 1933, represented the joint work of the Power Division's Executive Committee and the Water Hammer Committee of the Hydraulic Division of the American Society of Mechanical Engineers. It has been privately published under the auspices of the latter committee, and is available at a cost of $1.50 to members of the Society, the American Society of Mechanical Engineers, and the American Water Works Association, and $2 to others. Applications should be made to the American Society of Mechanical Engineers, 29 West 39th Street, New York City. Both committees may be justly proud of this outstanding and exhaustive treatise.

My paper on "The Silt Problem" (TRANSACTIONS, Vol. 101, page 207), which was stimulated and greatly aided by the Division's Committee on Silt, has just appeared in reprint form, with the discussion it elicited, nearly twelve years after the appointment of the committee. In this report will be found a summary of all data that could be found on the silt actually deposited in reservoirs and also that carried as suspended matter in the streams throughout the world.

The Committee on Legislation with Respect to Safety of Dams completed its work in a short time, only 3½ years having elapsed between the appointment of the committee and the presentation of its report to the Division. In the meantime, most Western states have enacted laws providing for the inspection of dams and making the state in some degree responsible for their safety.

I believe that the Board of Direction acts wisely in limiting the Power Division and other Divisions to activities involving the technical phases of the subject matter of each. The Engineering-Economics and Finance Division may properly consider economic questions from a broad viewpoint, and this arrangement keeps the economic phases of the question involved in one group. The Society does not act as censor nor try to control the papers presented at Division meetings. The programs for such meetings are arranged by the Regional Committee that logically follows the policies laid down by the Board. Yet even the Regional Committee seldom sees the papers prior to their presentation, nor does it wish to act as a censor. It seems wise, therefore, for the Board to outline certain general policies to be followed in selecting subjects for Division papers.

If the Power Division had launched on a wide discussion of public ownership of utilities, in its economic and political aspects from a fundamental standpoint, by having officials of corporate utilities present papers on that subject at Division meetings, it would have put the Society in an embarrassing position and all to no good purpose. People have opinions on the subject of public ownership as rigid and unchangeable as their views on politics and religion, and no amount of discussion can convert them. I am doubtless paraphrasing many proverbs when I say, "It's a wise man who knoweth when to keep his mouth shut."

J. C. STEVENS, M. Am. Soc. C.E.
Consulting Engineer

Portland, Ore.
May 23, 1937

Legislation and the Control of Land Adjacent to State Highways

TO THE EDITOR: In his article on "Rural Zoning and Highway Improvement," in the March issue, Laurance J. Carmalt, M. Am. Soc C.E., has set forth clearly the problems confronting state and municipal officials and that part of the public interested in the control of land adjacent to state highways. In the bulletin of the American Planning and Civic Association for October–November 1936, to which Mr. Carmalt referred, the following types of legislation are proposed:

1. State laws and regulations controlling outdoor advertising, chiefly by licensing provision and requirements for obtaining permits upon payment of fees. This method is in use in Maryland and North Carolina and has been proposed for the state of New York in several bills submitted to the legislature in recent years. In Massachusetts, Maine, New Jersey, Connecticut, and Vermont, this control is exercised not only by the issuance of licenses and the exaction of fees but also by specific restrictions concerning the location of sign boards.

2. City, town, and village prohibition of commercial structures, including billboards, by zoning. From the standpoint of protecting local sovereignty, there is much to commend this method. However, difficulty arises from the fact that so few of the local rural municipalities have as yet availed themselves of the zoning powers conferred upon them by the state legislature. This reluctance on the part of rural municipalities may be due in part to the fact that the governing officials are usually so well known to their neighborhood farmers that they hesitate to impose by governmental action any restrictions upon the uses of land fronting upon the highways.

3. County prohibition of commercial structures, including billboards, by zoning. In the Far West it has been found practicable to vest in county government the power that each rural municipality is accustomed to guard zealously for its own.

4. State regulations of the use of land abutting on state highways. This is the method advocated by the American Planning and Civic Association, and by such well-known students of zoning as Albert S. Bard and the late Dr. Robert Whitten, director of planning for the state of New York. However, state departments are reluctant to accept the responsibility for regulating the uses of private land in close proximity to state and county highways, because such regulation involves local zoning problems. Moreover, legislators are often reluctant to grant to a state department authority to control the uses of private lands within the jurisdiction of their counties and local towns for fear that the authority of the local rural government will be impaired.

5. State and county freeways and parkways. On this subject there may be said to be substantial agreement among the students of planning. The difficulties that arise are primarily those relating to the financing of such an undertaking. Although there is little evidence to support the view, it is commonly believed that the cost of acquiring a wider right of way than is now customary would be prohibitive and, in consequence, no state has made any substantial progress in this direction during the depression. With the advent of happier times, it is to be hoped that the fund derived from the gasoline tax and motor vehicle licenses will no longer have to be used for unemployment relief, and that there will thus be available sufficient money to finance the acquisition of rights of way and the construction of new highways on the freeway principle. It is confidently believed that where such freeways are constructed through open territory, the actual cost of acquiring the right of way will prove to be only a trifle more than the acquisition of the conventional narrower right of way. From the standpoint of traffic and public safety, the advantages of such freeways are many and obvious. A decline in accidents may confidently be expected through the control of access at safe and convenient intervals, and the resulting increase in the carrying capacity of the road should make these highways far more useful than the conventional type.

EUGENE H. CALLISON
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Albany, N.Y.
May 26, 1937

The Freeway an Expedient Only

TO THE EDITOR: In CIVIL ENGINEERING for January and April 1937, there is considerable discussion on highways, in which the word "freeway" has been prominent. If it is true, as stated in Information Bulletin No. 35 of the Regional Plan Association, Inc., of New York, that "a freeway is a strip of public land devoted to movement, over which the abutting owner has no right of light, air, or access," isn't it merely an expedient and not an ideal?

Where there has been a failure to provide sufficient width of public right of way for the proper development of the highway to meet the demands on it, and where the additional width needed for that purpose is not practically obtainable, a form of freeway may be an unavoidable solution. It is unfortunate, however, that the need for extra width was not foreseen and provided when obtainable so that the deficiencies of the freeway might be escaped.

As one discusser in the April issue of CIVIL ENGINEERING points out, "Unless modern standards are given more consideration, much of the work that is now being done will require major revision at public expense within a few years." Doesn't this truth underlie the problem for which the freeway expedient is offered as a solution and similar problems that are appearing almost universally?

Generally speaking, it seems that what is most needed—except perhaps in certain emergency cases through built-up districts—is more attention to the establishment of ample width of rights of way for highways and more effort towards the removal of obstacles (legal or other) in the way of attaining such an objective.

There is rapidly growing agreement among the more progressive highway experts and authorities that the "fairway," or divided roadway, and what might be called the "panel-way," or multiple-divided highway, are much more desirable stars to which to hitch our wagon than the freeway.

W. W. CROSBY, M. Am. Soc. C.E.
Consulting Engineer

Coronado, Calif.
May 27, 1937

Pressure Distribution and Acceleration at the Free Overfall

TO THE EDITOR: Walter B. Langbein, Jun. Am. Soc. C.E., is to be commended for his desire to develop a general analysis of flow conditions at the free overfall for all velocities of approach, as evidenced by his article on "Discharge Over a Free Fall," in the May issue, for falls at the end of supercritical slopes are frequently encountered in practice. Not only has this general case lacked a satisfactory analysis, but adequate experimental data upon which to base such an analysis are nowhere to be found.

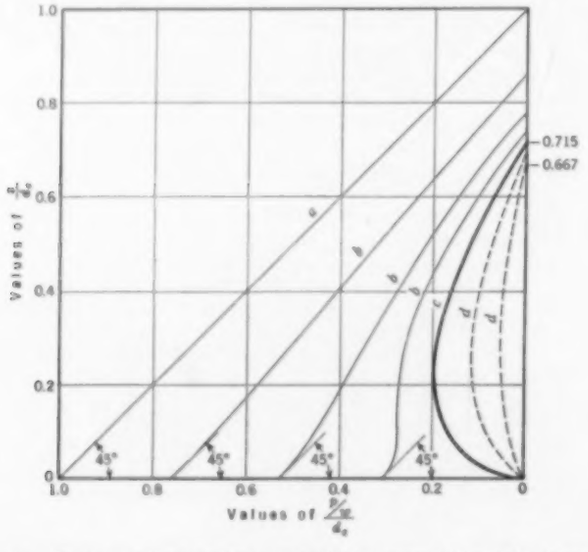


FIG. 1. DISTRIBUTION OF PRESSURE HEAD AT THE FREE OVERFALL
Showing Conditions (*a*) at the Critical Section Some Distance Upstream from the Crest; (*b*) at Intermediate Sections; (*c*) at the Crest; and (*d*) Within the Free Nappe.

Since Mr. Langbein's equations were not formulated on the basis of experimental evidence, they may not properly be termed empirical. And since certain of the assumptions upon which his developments depend are contrary to fact, the significance of his derivation is open to considerable question. That his equations yield the ratio $\frac{d_2}{d_c} = 0.71$ as a limiting condition, in close agreement with my measurements, is hardly sufficient verification.

The fallacy seems to lie with the initial assumptions as to pressure distribution and acceleration. Mr. Langbein's Fig. 1 shows a pressure diagram of concave form—a condition that is seldom found in such curvilinear motion. Actually, the convergence of the stream lines at the free fall produces a higher pressure intensity within the flow, with a pressure diagram that is convex over practically the entire section.

In the accompanying Fig. 1 are summarized, in dimensionless form, my measurements of pressure distribution at successive vertical sections of an overfall with horizontal approach. Both pressure head, $\frac{p}{w}$, and elevation above the lower boundary, z, are plotted in their ratio to the critical depth, d_c. These curves were obtained for a channel of zero slope, but they apply very closely to mild slopes as well. Moreover, the individual curves should be of the same general form for any velocity of approach above the critical, varying only in relative proportions.

In cases of such rapid acceleration, pressure and weight are the only acting forces of appreciable magnitude. The component of force per unit volume in any direction, y, may be written

$$f_y = -\frac{d(p + wz)}{dy}$$

Since the force per unit volume, f_y, divided by the mass per unit volume, ρ, must equal the acceleration in the corresponding direction,

$$a_y = \frac{f_y}{\rho} = -g\frac{d\left(\frac{p}{w} + z\right)}{dy}$$

If y represents vertical distance below the free surface, $dy = -dz$, and

$$a_y = g\left(1 - \frac{d(p/w)}{dy}\right)$$

So long as the pressure head increases in the y-direction, the acceleration will be less than g; similarly, if the pressure gradient becomes negative at any point, the acceleration will be greater than g by a corresponding amount. In the region of the fall, evidently, a_y must increase from the free surface downwards, because of the convex form of the pressure diagram. At the crest section, indeed, $d\frac{(p/w)}{dy}$ is decidedly negative in the lower portion of the flow, indicating a vertical acceleration considerably in excess of g. Nevertheless, at the floor itself the vertical acceleration must always have a magnitude of zero, since the lowermost stream line remains horizontal as far as the crest section. Hence, the slope of each pressure diagram must approach unity as a limit at the fixed boundary, as indicated in the illustration. The resulting concave portion of the diagram lies close to the floor, however, and becomes increasingly smaller in the direction of flow; at the crest this reversal of curvature entirely disappears.

It is reasonable to expect that the coefficient C in the expression

$$Q = Cbd_c^{3/2}$$

will increase with the velocity of approach, attaining the limit unity as the velocity becomes infinitely great. Despite unsound original assumptions, Eq. 2 of Mr. Langbein's paper thus indicates the proper trend. Should experimental data be found to substantiate this equation, hydraulics will add one more empirical paradox to the many which it now displays. It is only to be regretted that such occurrences tend to belie the desirability of sound physical analysis.

HUNTER ROUSE, Assoc. M. Am. Soc. C.E.

Pasadena, Calif.
May 24, 1937

DETROIT SKYLINE

Sixty-Seventh Annual Convention

Detroit, Mich., July 21–24, 1937

Hotel Statler to Be Headquarters

Opening Session and General Meeting

WEDNESDAY—July 21, 1937—Morning

9:00 **Registration**

10:00 **Sixty-Seventh Annual Convention called to order by**

GEORGE H. FENKELL, *M. Am. Soc. C.E., General Manager, Department of Water Supply*, Detroit, Mich.

10:05 **Addresses of Welcome**

THE HONORABLE LEO J. NOWICKI, *Assoc. M. Am. Soc. C.E., Lieutenant-Governor of the State of Michigan.*

RAYMOND J. KELLY, *Corporation Counsel representing* HIS HONOR FRANK COUZENS, *Mayor of the City of Detroit.*

10:15 **Response**

LOUIS C. HILL, *President, American Society of Civil Engineers; Consulting Engineer*, Los Angeles, Calif.

10:20 **Annual Address**

LOUIS C. HILL, *President, American Society of Civil Engineers.*

SYMPOSIUM ON THE TREND OF MODERN TRANSPORTATION

11:00 **Motor Vehicles and the Highways of the Future**

CHARLES F. KETTERING, *Esq., President, General Motors Research Corporation*, Detroit, Mich.

12:00 Business Meeting and Luncheon Recess.

WEDNESDAY—July 21, 1937—Afternoon

CONTINUATION OF SYMPOSIUM ON THE TREND OF MODERN TRANSPORTATION

2:00 **Highway Traffic and Motor Vehicle Taxation**

MURRAY D. VAN WAGONER, *Esq., Commissioner, Michigan State Highway Department*, Lansing, Mich.

Discussion opened by

FRANK T. SHEETS, *M. Am. Soc. C.E., Consulting Engineer, Portland Cement Association*, Chicago, Ill.

ROY W. CRUM, *M. Am. Soc. C.E., Director, Highway Research Board, National Research Council*, Washington, D.C.

3:15 **The Trend of Modern Highways**

THOMAS H. MACDONALD, *Esq., Chief, U. S. Bureau of Public Roads*, Washington, D.C.

Discussion opened by

FRED LAVIS, *M. Am. Soc. C.E., Consulting Engineer*, New York, N.Y.

BURTON W. MARSH, *M. Am. Soc. C.E., Director, Safety and Traffic Engineering Department, American Automobile Association*, Washington, D.C.

WEDNESDAY—July 21, 1937—Evening

7:00 **Dinner, Entertainment, and Dance**

Main Ball Room, Hotel Statler.

Members, ladies, and guests will assemble in the Ball Room of the Hotel Statler for dinner and entertainment.

Toastmaster, LEWIS M. GRAM, *M. Am. Soc. C.E., Professor of Civil Engineering, University of Michigan*, Ann Arbor, Mich.

Speaker, Mr. Edgar A. (Eddie) Guest.

Tickets for the dinner and evening's entertainment are $2.50 each.

Following the dinner and entertainment, there will be dancing

Technical Sessions Occupy

THURSDAY—July 22, 1937—Morning

HIGHWAY DIVISION

9:00 Trunk Line Highways in Metropolitan Areas

LEROY C. SMITH, *Assoc. M. Am. Soc. C.E., Chief Engineer, Wayne County Road Commission,* Detroit, Mich.

Discussion opened by

ROBERT KINGERY, *Esq., Secretary, Chicago Regional Planning Association,* Chicago, Ill.

10:30 The Place of the Express Highway in a Modern Road System

JOHN S. CRANDELL, *M. Am. Soc. C.E., Professor, Highway Engineering, University of Illinois,* Urbana, Ill.

Discussion opened by

ROBERT B. BROOKS, *M. Am. Soc. C.E., Consulting Engineer,* St. Louis, Mo.

S. JOHANNESSON, *M. Am. Soc. C.E., Designing Engineer, State Highway Commission,* Trenton, N.J.

JOHN S. WORLEY, *M. Am. Soc. C.E., Professor of Transportation Engineering, University of Michigan,* Ann Arbor, Mich.

DIX BASCULE BRIDGE

WATERWAYS DIVISION

9:00 Transportation on the Great Lakes

M. C. TYLER, *M. Am. Soc. C.E., Brigadier-General, Corps of Engineers, U.S.A., Assistant to Chief of Engineers, War Department,* Washington, D.C.

Discussion opened by

JOHN S. WORLEY, *M. Am. Soc. C.E., Professor of Transportation Engineering, University of Michigan,* Ann Arbor, Mich.

10:30 Proposed Compensatory Works in the St. Clair River

C. R. PETTIS, *M. Am. Soc. C.E., Colonel, Corps of Engineers, U.S.A., District Engineer, U. S. Lake Survey Office,* Detroit, Mich., and SHERMAN MOORE, *Esq., Senior Engineer, U. S. Lake Survey,* Detroit, Mich.

Discussion opened by

C. O. WISLER, *M. Am. Soc C.E., Professor, Hydraulic Engineering, University of Michigan,* Ann Arbor, Mich.

CITY PLANNING DIVISION

9:00 Need for Sub-Surface Utility Planning

ARTHUR W. CONSOER, *M. Am. Soc. C.E., President and General Manager, Consoer, Townsend and Quinlan,* Chicago, Ill.

Discussion opened by

L. G. LENHARDT, *M. Am. Soc. C.E., Commissioner, Department of Public Works,* Detroit, Mich.

J. B. GORDON, *M. Am. Soc. C.E., Director, Sanitary Engineering, District of Columbia,* Washington, D.C.

10:30 Basic Principles in Sub-Surface Utility Planning

H. H. KRANZ, *M. Am. Soc. C.E., Engineer of Highways,* Cincinnati, Ohio.

Discussion opened by

L. R. MAPES, *Esq., Chief Engineer, Chicago Area, Illinois Bell Telephone Company,* Chicago, Ill.

GEORGE M. SHEPARD, *M. Am. Soc. C.E., Chief Engineer, Department of Public Works,* St. Paul, Minn.

SIX-MILE ROAD OVER MIDDLE ROUGE HIGHWAY

Thursday and Friday Forenoons

FRIDAY—July 23, 1937—Morning

SANITARY ENGINEERING DIVISION

9:00 **Tourist Camp and Roadside Sanitation**

EDWARD D. RICH, *M. Am. Soc. C.E., Engineer, Bureau of Engineering, Michigan Department of Health,* Lansing, Mich.

Discussion opened by

B. A. POOLE, *Esq., Chief Engineer, Indiana State Department of Health,* Indianapolis, Ind.

FRANK G. LEGG, JR., *Assoc. M. Am. Soc. C.E., Sanitary Engineer, Detroit Department of Health,* Detroit, Mich.

C. W. KLASSEN, *Esq., Chief Engineer, Illinois State Department of Health,* Springfield, Ill.

10:00 **Seal of Safety Roadside Water Supply Program**

F. D. STEWART, *M. Am. Soc. C.E., Principal Assistant Engineer, Sanitary Engineering Division, State Department of Health,* Columbus, Ohio.

Discussion opened by

E. S. TISDALE, *Esq., Director, Division of Sanitary Engineering, West Virginia State Department of Health,* Charleston, W.Va.

11:00 **Relationship of Full Time Health Service to Travel Safety**

K. E. MILLER, *Esq., Senior Surgeon and Assistant Chief, Domestic Quarantine Division, U. S. Public Health Service,* Washington, D.C.

Discussion opened by

HENRY F. VAUGHAN, *Assoc. M. Am. Soc. C.E., Commissioner of Health,* Detroit, Mich.

MIDDLE ROUGE PARKWAY DRIVE

GENERAL SESSION

9:00 **The Proposed Mackinac Straits Bridge**

JAMES H. CISSEL, *M. Am. Soc. C.E., Professor, Structural Engineering, University of Michigan,* Ann Arbor, Mich.

Discussion opened by

C. F. GOODRICH, *M. Am. Soc. C.E., Chief Engineer, American Bridge Company,* Pittsburgh, Pa.

CARLTON S. PROCTOR, *M. Am. Soc. C.E., Consulting Engineer, New York, N.Y.*

DETROIT AT NIGHT

Social Events and Ladies Entertainment

Entertainment for the Ladies

WEDNESDAY—July 21, 1937

11:00 Ladies' Luncheon and Bridge at the Detroit Yacht Club

Luncheon—MRS. F. O. CLEMENTS, *Chairman.*

Bridge Party—MRS. L. G. LENHARDT, *Chairman.*

Ladies will leave the Hotel Statler at 11:00 a.m. for a drive to the Detroit Yacht Club where luncheon will be served.

The Detroit Yacht Club is located at the middle of the Detroit side of Belle Isle. It is the great club of Detroit's waterfront, where hundreds of yachts, including some of the finest on the Great Lakes, are to be seen. Broad porches are ideal for rest and for watching the activities of Detroit's aquatic playground. Within are spacious rooms for dancing, dining, and other activities.

The party will be entertained at bridge in the afternoon, returning to the hotel about 6:00 p.m.

There will be no charge for tickets.

7:00 Dinner, Entertainment, and Dance

Ladies will join the members for the dinner and entertainment at the Hotel Statler.

FRIDAY—July 23, 1937—Afternoon

2:00 Visit to Detroit Zoological Park

MRS. WINSTON MATHER, *Chairman*

Ladies and others interested will leave the Hotel Statler at 2:00 p.m. for a visit to the Detroit Zoological Park, known as one of the largest and finest in the country and unique in many of its features.

There will be no charge for tickets to ladies.

THURSDAY—July 22, 1937—Morning and Afternoon

11:00 Ladies to Spend Day at Greenfield Village

Trips through Greenfield Village—MRS. J. W. ORTON, *Chairman.*

Luncheon, Dearborn Inn—MRS. F. E. WEBER, *Chariman.*

Ladies will leave the Hotel Statler by bus at 11:00 a.m. for a day's visit to the Greenfield Village at Dearborn. The morning will be spent in visiting points of interest about the Village, following which luncheon will be served at the Dearborn Inn.

The Dearborn Inn is one of the finest and quietest hotels in Michigan. Built and managed by Mr. Henry Ford, it is an important unit in the institutions that he has built up in Dearborn. The architecture is colonial and in harmony with the buildings of Greenfield Village which is located nearby.

In the afternoon, the party will visit the Ford Museum, returning to the hotel about 6:00 p.m.

There will be a nominal charge for the luncheon.

Thursday and Friday Luncheons

THURSDAY—July 22, 1937

12:15 Luncheon for men at Hotel Statler

WILLIAM C. HIRN, *M. Am. Soc. C.E., President, Detroit Section, Presiding*

At the close of the sessions on Thursday, members and men guests will gather for luncheon in the Hotel Statler.

ARTHUR E. MORGAN, *M. Am. Soc. C.E., Chairman, Board of Directors, Tennessee Valley Authority,* will address the gathering. Tickets are $1.50 each.

FRIDAY—July 23, 1937

12:00 Luncheon at Hotel Statler

Members, ladies, and guests will gather for luncheon at the Hotel Statler.

MR. J. H. HUNT, *of the General Motors Corporation,* will address the gathering on the Aims and Activities of the recently organized Engineering Society of Detroit.

Tickets for the luncheon are $1.25 each.

AIRVIEW OF BELLE ISLE

DETROIT YACHT CLUB ON BELLE ISLE

THURSDAY—July 22, 1937—Evening

8:30 Moonlight Boat Ride on "Put-in-Bay"

Weather permitting, members, ladies, and guests will go on a "Moonlight Sail" on Put-in-Bay.

Music, dancing, and refreshments.

Tickets for the trip and evening's entertainment are $1.50 each. No charge for ladies.

Excursions and Recreations

Variety of Trips Scheduled for Thursday, Friday, and Saturday

TWO EXCURSIONS FOR THURSDAY AFTERNOON, JULY 22, 1937

(1) **Springwells Station and Dearborn Sewage Treatment Plant**

(2) **The Ambassador Bridge Loop, Belle Isle, and Lake Shore Drive**

Buses for both trips will leave the Hotel Statler at 2:00 p.m., and return about 6:00 p.m.

Trip No. 1—Springwells Station, and the Dearborn Sewage Treatment Plant

The Springwells Station of the Detroit Water Supply, which is described at length in the 1936 TRANSACTIONS of the Society, obtains its water supply from the Detroit River at the head of Belle Isle. The water flows by gravity at a depth of 90 ft under the city of Detroit to the plant where it is pumped to the rapid sand filters. Built recently at a cost of $35,000,000, it is one of the finest plants in the country. The buildings are of Indiana limestone.

The Dearborn Sewage Treatment Plant is a modern plant employing chemical treatment with Laughlin filter equipped circular settling basins. Sewage sludge is disposed of by incineration. The building which houses the entire plant is of colonial architecture and of such fine appearance that it would not be unwelcome to a residential section.

Tickets for the trip are 75 cents each.

SPRINGWELLS STATION, DETROIT WATER SUPPLY DEPARTMENT

Trip No. 2—The Ambassador Bridge Loop, Belle Isle, and Lake Shore Drive

Due to immigration and customs regulations, the buses will proceed over the Ambassador Bridge and return without passage through the Canadian customs. They will then proceed to Belle Isle, passing the entrance of the Detroit-Windsor Tunnel. A circuit of Belle Isle, which is three miles long, contains 985 acres, and has one of the ten largest parks in the world, will be made. At the north end is the beautiful Livingston Lighthouse whose beacon helps to guide the heaviest tonnage of the world past the Canadian side of the Island. Going down the Detroit side of the island, the buses will pass the great municipal bath house, the island's zoological park, and the police radio station.

Leaving the island over the same beautiful concrete bridge by which they arrived, the buses will turn north from the bridge and proceed over Jefferson Avenue to the Lake Shore Drive which borders Lake St. Clair. This is a new highway built on fill pumped from the lake, beautifully landscaped and lined on one side by some of the most magnificent homes of Detroit. The drive is one of the finest of its kind in North America. At the estate of Mr. Edsel Ford, the buses will turn and retrace their route, returning directly to the hotel.

Tickets for the trip are 75 cents each.

Golf Tournament

Arrangements have been made for a golf tournament for those who may prefer recreation instead of sightseeing.

EXCURSION TO DETROIT ZOOLOGICAL PARK FOR FRIDAY AFTERNOON, JULY 23, 1937

Buses for the trip will leave the Hotel Statler at 2:00 p.m., and return about 6:00 p.m.

In visiting the Detroit Zoological Park, which is outside the city, the route will lie over Woodward Avenue within

POLAR BEAR GROUP, DETROIT ZOOLOGICAL PARK

the city and its great superhighway beyond. These are splendid examples of the manner in which Detroit is meeting its great traffic problem.

In the return, the route will be the same except for a diversion through Palmer Park, a beautiful residential section.

The zoo is a visit for even globe trotters to remember. The wildest of animals may be seen in what appears to be their natural habitat without a bar or fence to mar the scene. Bears, black, brown and white, as well as shaggy lions may be seen in groups prowling about their great cliffs and lounging at the bases of the cliffs. The rhinoceros, giraffe, ostrich, and numerous lesser animals and birds may be seen in settings that are a delight to everyone.

Tickets for the trip are 75 cents each for men. No charge for ladies.

TRIP OVER WAYNE COUNTY HIGHWAYS AND PARKS, SATURDAY MORNING, JULY 24, 1937

9:00 Buses will leave the Hotel Statler at 9:00 a.m., returning at 12:30 p.m.

Through the courtesy of the Highway Department of Wayne County, members will have the opportunity of taking a trip over 75 to 80 miles of highway and park developments. The important elements of the trip will be the superhighways, roadside developments, comfort stations, parkways, rigid-frame concrete bridges, a bascule bridge with open steel deckings, grade separations (including the South Field Road, Michigan Avenue, Cloverleaf), and numerous less important details.

There will be no charge for tickets.

GRADE SEPARATION AND HIGHWAY LIGHTING

Hotel Accommodations and Announcements

Hotel Rates

HOTEL	WITH BATH SINGLE	WITH BATH DOUBLE	WITHOUT BATH SINGLE	WITHOUT BATH DOUBLE
Statler	$2.50 up	$4.50 up	....	....
Book-Cadillac	3.00 up	5.00 up	....	....
Detroit-Leland	2.50 up	3.50 up	....	....
Briggs	2.00 up	3.00 up	....	....
Madison-Lenox	1.50 up	2.00 up	....	....

Members are urged to make definite arrangements at least a week in advance of the Annual Convention.

There will be no increase in the regular rates at any of the hotels during the Convention.

The Hotel Statler is the Society Headquarters for the Convention.

All who attend the Annual Convention are requested to register immediately upon arrival at Meeting Headquarters. Special badges and tickets will be obtained at the time of registration.

Information

A registration desk will be provided in the Headquarters Hotel to assist visiting members in securing any desired information about the city. At the registration desk, a card file of those in attendance will be maintained, with information as to members' Detroit addresses.

Local Sections Conference

On Tuesday afternoon, July 20, 1937, at the Michigan Union, Ann Arbor, there will be a conference of delegates from the 30 Local Sections in the Northern Meeting Region with the Society's Committee on Local Sections and the Northern Region Meetings Committee.

A comprehensive agenda has been prepared for the discussion of activities of mutual interest to the Local Sections.

All interested members are invited to attend and participate in the conference.

Entertainment, Golf, and Special Trips

Attention is directed to the program for the entertainment of the ladies. The ladies are cordially invited to participate in all the other features of the meeting that may interest them.

Members who wish to play golf or visit places of individual interest are directed to the Registration Desk.

Order All Tickets in Advance

Members who order tickets in advance will not only be saved annoyance and delay by having tickets and badges awaiting them on arrival at Headquarters, but they will assist the committee greatly by giving advance information to guide it in concluding arrangements.

See page 30 in back of this issue for registration and ticket order forms.

Make reservations directly with the hotel or through the Local Committee as early as possible and thus avoid inconveniences and delays. Any requests addressed to G. H. Fenkell, M. Am. Soc. C.E., General Chairman, 735 Randolph Street, Detroit, Mich., will be promptly attended to.

Invitation to Student Members

Members of Student Chapters are invited to attend and participate in all the events of the Annual Convention.

Local Committees on Arrangements

G. H. FENKELL, *General Chairman*
W. C. HIRN, *President, Detroit Section*
L. C. WILCOXEN, *Secretary and Treasurer, Detroit Section*
F. E. WEBER, *Treasurer of Local Committee*
H. E. RIGGS, *Former Vice-President, Am. Soc. C.E.*

Program

L. G. LENHARDT, *Chairman*
H. E. RIGGS — L. C. WILCOXEN

Finance

H. E. RIGGS, *Chairman*
G. H. FENKELL — W. R. KALES
F. C. MCMATH — F. E. WEBER

Local Transportation

F. G. LEGG, JR., *Chairman*
C. R. BIRD — W. R. DUNHAM
H. A. SHUPTRINE

Outside Transportation

PAUL CHIPMAN, *Chairman*

Entertainment

L. E. AYRES, *Chairman*
R. L. MCNAMEE — M. F. OHR
E. H. PATE

Press

A. B. MORRILL, *Chairman*

Notices and Invitations

E. A. HARDIN, *Chairman*
H. E. RIGGS — W. S. WOLFE

Registration and Hotel

D. C. GROBBEL, *Chairman*
D. NEWTON

Reception

A. L. TROUT, *Chairman*
A. S. DOUGLASS — C. W. HUBBELL
L. M. GRAM — C. C. JOHNSTON
D. R. WELLS

Excursion

M. R. FISHER, *Chairman*
J. W. ORTON — M. J. QUINN

Information

W. H. ADAMS, *Chairman*
F. E. SIMPSON

Ladies Committee

MRS. GEORGE H. FENKELL, *General Chairman*

MRS. W. H. ADAMS	MRS. WINSTON MATHER
MRS. L. E. AYRES	MRS. F. N. MENEFEE
MRS. FRANK BURTON	MRS. A. B. MORRILL
MRS. F. O. CLEMENTS	MRS. R. L. MORRISON
MRS. A. S. DOUGLASS	MRS. LEO J. NOWICKI
MRS. DOUGLAS DOW	MRS. MILO F. OHR
MRS. NEAL FENKELL	MRS. J. W. ORTON
MRS. MARTIN R. FISHER	MRS. HENRY E. RIGGS
MRS. E. A. HARDIN	MRS. H. A. SHUPTRINE
MRS. W. C. HIRN	MRS. F. E. SIMPSON
MRS. C. W. HUBBELL	MRS. L. C. SMITH
MRS. J. H. HUNT	MRS. GEORGE R. THOMPSON
MRS. JOHN W. KENNEDY	MRS. F. E. WEBER
MRS. F. GARDNER LEGG, JR.	MRS. L. C. WILCOXEN
MRS. L. G. LENHARDT	MRS. HARRY WOLF

Luncheon, Detroit Yacht Club

MRS. F. O. CLEMENTS, *Chairman*

Bridge Party, Detroit Yacht Club

MRS. L. G. LENHARDT, *Chairman*

Trips Through Greenfield Village

MRS. J. W. ORTON, *Chairman*

Luncheon, Dearborn Inn

MRS. F. E. WEBER, *Chairman*

Hospitality

MRS. F. GARDNER LEGG, JR., *Chairman*

Trip to Zoological Park

MRS. WINSTON MATHER, *Chairman*

The program as a whole has been prepared under the direction of the Committee on Regional Meetings, composed of R. C. GOWDY, *Vice-President, Am. Soc. C.E., Chairman;* and JAMES L. FEREBEE, C. B. BURDICK, HOWARD S. MORSE, and T. A. LEISEN, *Directors, Am. Soc. C.E.*

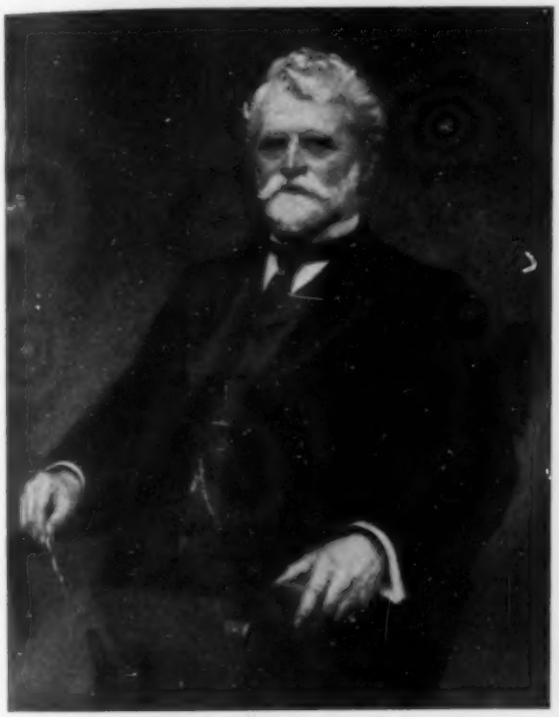
Please call on the Local Committee on Arrangements or on the Secretary's office for any service desired.

SOCIETY AFFAIRS

Official and Semi-Official

Ambrose Swasey, 1846–1937

FULL OF YEARS, widely honored, and loved by all, Ambrose Swasey, Hon. M. Am. Soc. C.E., died at his summer home in Exeter, N.H., on June 15. He was in his 91st year. The story of his life reads like that of a Horatio Alger hero. In fact, he was a product of that same generation. He was the poor but upright boy who, by virtue of character, industry, and ability, became indeed great—the friend of rulers, the benefactor of mankind.



AMBROSE SWASEY

His early training, after common schooling, was in manufacturing in New Hampshire and Connecticut. In 1880 he joined with his friend Worcester R. Warner in establishing a life-long partnership, the Warner and Swasey Company. This company was located in Cleveland, Ohio, where it manufactured precision machines and instruments. Largely as a result of the two men's business and scientific attainments, the company has grown to the status of one of the great manufacturers in its important field. Mr. Swasey's early interest in astronomy and the manufacture of his first telescope led to the contract for the great telescope for the Lick Observatory, followed later by those for the Yerkes and U. S. Naval Observatories.

During his life Mr. Swasey gave generously to religious and educational institutions. It was he who instituted and endowed the Engineering Foundation, which has done so much for practical research in all branches of the profession. His high standing in engineering circles is evidenced by the great number of honors bestowed upon him: the Franklin Institute Award; the Hoover Gold Medal; the VDI (Verein Deutscher Ingenieure) Medal; the John Fritz Gold Medal; the A.S.M.E. Medal; and the Washington Award. He also held honorary doctorates. In 1904 he was president of the American Society of Mechanical Engineers. He was elected Honorary Member of the American Society of Civil Engineers in 1921.

His venerable figure and genial personality were prominent at many engineering meetings, even in recent days. Such were his character and ideals that he held a preeminent niche in the honor and affection of the profession. In the death of Ambrose Swasey, engineering loses one of its "grand old men."

Division Holds First Technical Meeting

West Coast Session on Soil Mechanics and Foundations

THE PACIFIC COAST membership of the Soil Mechanics and Foundations Division met Saturday, May 22, 1937, in an all-day technical session at the California Institute of Technology, Pasadena. This meeting, held under the auspices of the Los Angeles Section, marks the first gathering of any large portion of the membership since the Division was authorized on July 13, 1936. The participants included engineers not only from the western part of the United States but also from such distant points as Australia, and the total registration of 150 clearly showed the lively and gratifying interest this new field commands.

Franklin Thomas, M. Am. Soc. C.E., as chairman of the local committee, presided at the opening session. In his introductory remarks he briefly sketched the history of the Division and gave credit to R. V. Labarre, M. Am. Soc. C.E., member of the Executive Committee of the Division, for calling the meeting and organizing its program.

A paper on "The Control of Landslides Through Drainage," was read by Robert G. Hennes, Assoc. M. Am. Soc. C.E. In this paper Mr. Hennes analyzed the factors involved, considered their order of importance, and suggested the limitations of corrective measures. The discussion was led by Raymond A. Hill, M. Am. Soc. C.E., who described the slides that occurred in the emptied San Francisquito Reservoir after the failure of the dam, and the stabilization of a large slide affecting portions of the Santa Monica Palisades. William W. Moore, Jun. Am. Soc. C.E., read a discussion emphasizing the fact that stress in soil, as in all other materials, is always accompanied by deflection.

The second paper of the morning, "Soil Mechanics in Connection with the Construction of the San Gabriel Dam," was presented by Paul Baumann, M. Am. Soc. C.E. In this paper Mr. Baumann described laboratory and field practice used in the control of construction of this 400-ft high, rock-fill dam, and presented certain research done in attempting to correlate plasticity-needle readings with the stability of the embankment material. The lively discussion that followed was led by R. R. Proctor, M. Am. Soc. C.E., who took issue with certain of Mr. Baumann's results. Trent R. Dames, Jun. Am. Soc. C.E., discussed settlement and shear tests, the values obtained and their use.

The first paper of the afternoon, "Selected Features of Earth Dam Construction as Practiced by the Bureau of Reclamation," was presented by Donald P. Barnes, Assoc. M. Am. Soc. C.E. This largely descriptive paper was elaborately illustrated with slides, and depicted the latest practice of the U. S. Bureau of Reclamation in field and laboratory. In his discussion of this paper N. F. Crossley gave an illuminating description of the construction of Cajalco Dam, for the Metropolitan Water District of Southern California.

The final paper of the day, "Investigation of Pressure Distribution Under Footings and Settlement of Foundations," was presented by Frederick J. Converse, Assoc. M. Am. Soc. C.E. He described certain experimental determinations of pressure distributions under variously loaded and proportioned footings, and announced a program for including pressure cells in the footings of the Mudd Geological Laboratories, soon to be built on the campus of the California Institute of Technology. Following this paper the floor was opened to an informal question hour, and discussion then ran the gamut from the cost of rolled fill on the Tri-County Project, Nebraska, to settlements of buildings in San Francisco.

Inspection of the engineering laboratories of the Institute was followed by a dinner in the Athenaeum. Abetted by the consumption of large and excellent steaks, a spirit of geniality permeated the gathering.

Everyone listened with pleasure to Dr. John P. Buwalda, chairman, Division of Geology, California Institute of Technology,

who spoke on "The Geological History and Structure of the Coast Region of Southern California." He stressed certain of the geologic reasons for many of the soil mechanics and foundations problems that exist in this region today.

Participants in this meeting separated with a feeling of value received, and of looking forward to future sessions.

The foregoing report was prepared for CIVIL ENGINEERING by Trent R. Dames, Jun. Am. Soc. C.E.

Junior Groups Report on Year's Activities

"TO PROMOTE an active interest among Juniors in the aims and activities of the Society; to encourage fellowship and cooperation; and to provide practice in conducting meetings." Though stated in various ways in their respective constitutions, these are the common aims of the six associations of Juniors now carrying on their activities in Los Angeles, San Francisco, Denver, Chicago, Philadelphia, and New York.

How do they function? What is their program? What special projects are under way in one group that might be of value to another? These questions the present article attempts to answer.

The organizational set-up of the individual groups ranges from the formal scheme of the Metropolitan Juniors to the somewhat complex "rotating committee" plan in use at San Francisco and Denver. The New York group elects an executive committee, consisting of a president, two vice-presidents, a secretary, and a treasurer, to serve for a full year. These officers plan the programs and perform most of the administrative functions of the Branch. On the other hand, the San Francisco Forum is guided by an advisory committee of three members. One of them is the retiring secretary; the others are elected directly, and the terms are staggered so that one new member takes office every four months. The program is in the hands of a second rotating committee of three; each member serves for a period that includes three regular meetings of the Forum, is chairman of the committee during the last third of the term, and names his own successor after consultation with the other two committeemen and the secretary.

There is close cooperation between the Junior groups and their respective Local Sections. The latter supply what funds are necessary for postage and incidental expenses, and maintain contact with the former through special committees and individual members. The Juniors, on their part, contribute in various ways to the work of the Sections. In San Francisco, for example, members of the Junior Forum are serving on all the committees of the Local Section, and one committee (on excursions) is composed entirely of Juniors. In Los Angeles and Philadelphia Juniors provide the program for the May meeting of the Section, and the Colorado Juniors conduct two Local Section meetings, one of which is the annual "Ladies' Night." In New York one Section meeting is largely given over to the final round of the annual public speaking contest.

As to type of program, the various Junior groups follow three distinct lines. In Chicago and New York, most of the meetings feature an address by an "outside" speaker—that is, some one other than a Junior. Of course, a general discussion follows the address. Los Angeles and San Francisco, on the other hand, draw their talent mainly from their own group. The Los Angeles secretary writes: "It is felt to be more desirable to use members of the local group or from the local Student Chapters, as this gives them an opportunity to gain experience in the preparation and presentation of papers that would not be possible in the regular meetings of the Local Section."

The third type of program was launched in Philadelphia a few months ago. It is described as a "program of professional development," and "involves the formation of small groups or committees to study and discuss particular technical problems." A group is organized by common consent of a number of interested Juniors, and any group thus formed "will have the assistance of one or more Section members in an advisory capacity." At present one group is already under way. It meets monthly to study "Structural Problems" and "The Engineer and His Relation to Social Life."

What is the favorite type of subject for Junior meetings? The Metropolitan group has for two consecutive years drawn its heaviest attendance at an address explaining the requirements of the state licensing law and the method of making application. Colorado finds that "an engineering program of educational value" seems to attract the largest audience. Examples are "Geophysics Applied to Engineering" and "Practical Engineering Geology." San Francisco divides each meeting into halves; the first topic "is usually some current event. A non-engineering subject is chosen to give the members a chance to broaden the scope of their knowledge. Discussion is led by an appointed member." The second part of the program features a subject of technical interest, and is also followed by discussion.

At least three Junior groups are sponsoring special activities in addition to those mentioned. Colorado shows a special interest in inspection trips, and during the past season has conducted at least five. Included in the list are visits to a broadcasting station, a sugar factory, and the Colorado Museum of Natural History.

Illinois stresses the value of publicity to the engineering profession as a whole. A committee is now investigating the possibility of obtaining time from one of the local broadcasting stations "for a program designed to interest the general public in the value of the engineer to society." Another committee of the Illinois Juniors should also be mentioned; its purpose is to get in touch with Juniors not affiliated with the Illinois Section and introduce them to its activities.

A course in effective speaking (financed by the Metropolitan Section) is provided for the New York Juniors. During the past season the class met once a month for instruction and practice. The instructor concentrates on the presentation of "appeal type" speeches, and purely technical subjects are essentially taboo. By elimination, four members of the class are selected to participate in a contest which takes place at a regular meeting of the Local Section in May.

The information in the preceding paragraphs has been gathered from detailed reports supplied by P. S. Bailey, Assoc. M. Am. Soc. C.E., and Frederick L. Weiss, C. L. Waterbury, E. Stanley Lord, George L. Curtis, and A. Harry Wagner, all Juniors Am. Soc. C.E.

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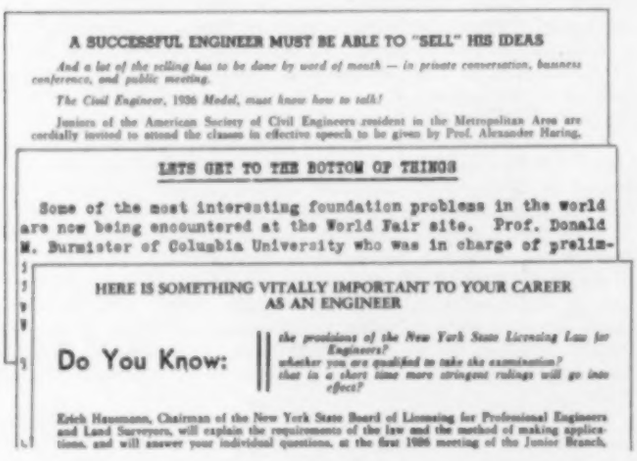

A SUCCESSFUL ENGINEER MUST BE ABLE TO "SELL" HIS IDEAS
And a lot of the selling has to be done by word of mouth — in private conversation, business conference, and public meeting.
The Civil Engineer, 1936 Model, must know how to talk!
Juniors of the American Society of Civil Engineers resident in the Metropolitan Area are cordially invited to attend the classes in effective speech to be given by Prof. Alexander Haring.
LETS GET TO THE BOTTOM OF THINGS
Some of the most interesting foundation problems in the world are now being encountered at the World Fair site. Prof. Donald M. Burmister of Columbia University who was in charge of prelim-
HERE IS SOMETHING VITALLY IMPORTANT TO YOUR CAREER AS AN ENGINEER
Do You Know:
the provisions of the New York State Licensing Law for Engineers?
whether you are qualified to take the examination?
that in a short time more stringent rulings will go into effect?
Erich Hausmann, Chairman of the New York State Board of Licensing for Professional Engineers and Land Surveyors, will explain the requirements of the law and the method of making applications, and will answer your individual questions, at the first 1936 meeting of the Junior Branch.

SALESMANSHIP IN MEETING ANNOUNCEMENTS

The Junior Branch of the Metropolitan Section Tries to Make Sure That Its Postcards Will Be Read

Detroit Convention at Hand

WITH THE COMPLETION of plans for the 67th Annual Convention of the Society, to be held in Detroit, Mich., July 21–24, 1937, this gathering promises to be one of the most notable of recent years. Among other advantages, it brings to the Middle West a summer convention for the first time in a long while. It thus affords an opportunity for a large number of members to combine a worthwhile vacation with a Society meeting under excellent auspices and in pleasant surroundings.

A mere glance at the official program, given elsewhere in this issue, will serve to convince those who have been considering attending the meeting. The "automobile city" offers much to the summer visitor, so the ladies will find many attractions, while

DETROIT—INDUSTRIAL METROPOLIS OF THE MIDDLE WEST

the men are enjoying the technical sessions. It is fitting that transportation in its varied phases should be given a prominent place. In fact, in the development of the whole program, a sense of proportion and of variety is very evident.

Such complete plans for the enlightenment and entertainment of guests are the best guarantee of a worth-while gathering. And this long-awaited meeting, combining the finest technical and social features, conveniently arranged and located to appeal to a large number of the membership, should ensure a record attendance. Headquarters for the meeting and the sessions will be at the Hotel Statler.

Engineering Institute of Canada Celebrates Semi-Centennial

COMMEMORATING fifty years of service and progress, the Engineering Institute of Canada held notable meetings in Montreal and Ottawa, June 15–18, 1937. Both technical and social gatherings were provided on a generous scale, and engineers from throughout Canada as well as Great Britain and the United States joined in the happy celebration.

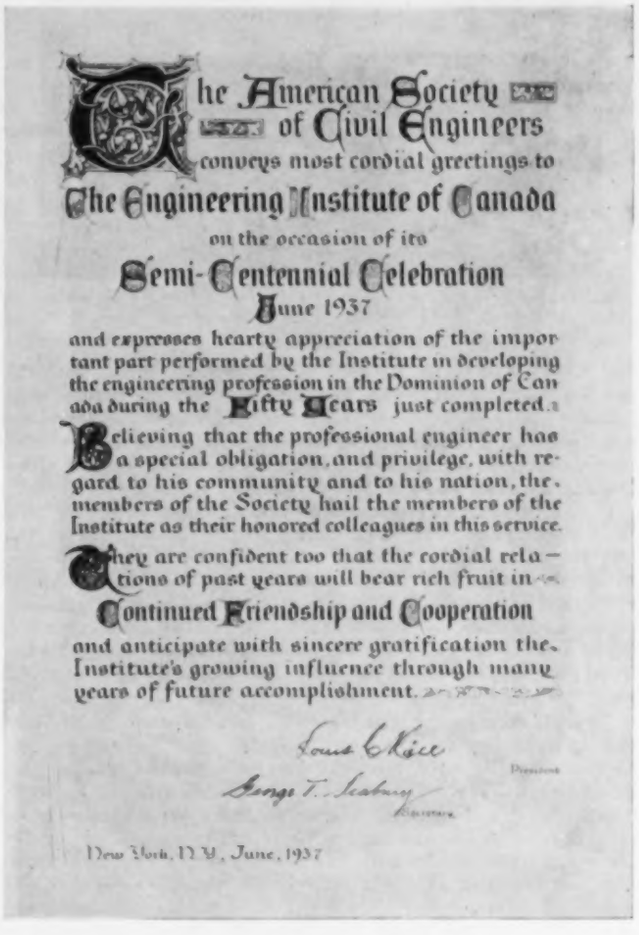
On Tuesday, June 15, at the opening session, interesting formalities were completed, including presentation of greetings such as that of the Society illustrated in the accompanying reproduction. It was then, also, that honorary memberships were bestowed; One of these was to have been given to Harrison P. Eddy, Past-President, Am. Soc. C.E., had he lived to receive this distinction.

That and the following days were devoted also to several sessions for presentation of technical papers and discussions, comprising the more scientific part of the entire celebration. This phase of the meeting was concluded on Wednesday afternoon.

On Wednesday evening the Semi-Centennial Banquet was enjoyed at the Windsor Hotel. This indeed was a notable event, graced by His Excellency, Lord Tweedsmuir, Governor-General of Canada. On this occasion, the Society representative, Vice-President Edward P. Lupfer, was privileged to offer the evening's toast to the Institute, with all the good will of the sister organization.

Many trips to points of engineering interests in and about Montreal were arranged for Thursday, with garden parties, concerts, and other social events to vary the program. Then on Friday the celebration moved by automobile and train to Ottawa, where the day was spent in planned events of both technical and general interest, supplemented by a dinner-dance in the evening.

The presence of eminent engineers from America and abroad added to this notable celebration. The Institute also issued a special number of its Journal for the event. All in all, the happy week of meetings and sociability made it possible for many friends of the Institute to express by word and action their joy in its fine record; and it permitted the Institute, while reviewing its fifty successful years, to look forward with increasing confidence to an even more glorious future.



The American Society of Civil Engineers
conveys most cordial greetings to
The Engineering Institute of Canada
on the occasion of its
Semi-Centennial Celebration
June 1937
and expresses hearty appreciation of the important part performed by the Institute in developing the engineering profession in the Dominion of Canada during the Fifty Years just completed.

Believing that the professional engineer has a special obligation, and privilege, with regard to his community and to his nation, the members of the Society hail the members of the Institute as their honored colleagues in this service.

They are confident too that the cordial relations of past years will bear rich fruit in
Continued Friendship and Cooperation
and anticipate with sincere gratification the Institute's growing influence through many years of future accomplishment.

Louis C. Hill
President
George T. Seabury
Secretary

New York, N. Y., June, 1937

ILLUMINATED MEMORIAL PRESENTED TO THE ENGINEERING INSTITUTE OF CANADA ON THE OCCASION OF ITS SEMI-CENTENIAL CELEBRATION, JUNE 15, 1937

The Original Is 12 by 16-In. Parchment, Decorated with Gold Leaf and Brilliant Water Colors

Past-President Harrison P. Eddy

A NOTABLE CAREER of continued usefulness and increasing honor was suddenly cut short when Harrison P. Eddy, Past-President, Am. Soc. C.E., was stricken with fatal illness in Montreal early Tuesday morning, June 15. Few men in the engineering profession were more highly respected or more deeply loved.

Born and trained in New England, Mr. Eddy spent practically all his professional life within fifty miles of Boston. After his graduation from Worcester Polytechnic Institute in 1891, he served for fifteen years as superintendent in charge of the Worcester Sewage Treatment Plant. He gave up this work to found, with the late Leonard Metcalf, Assoc. M. Am. Soc. C.E., the firm of Metcalf and Eddy with offices in Boston. This firm has for many years acted in a consulting capacity on some of the largest sanitary projects in America, including those in Milwaukee, New Orleans, Detroit, Buffalo, Pittsburgh, and Rochester.

HARRISON P. EDDY—1870–1937

One of Mr. Eddy's latest major responsibilities was on the new Washington plant. There he served with his life-long friend, the late John H. Gregory, M. Am. Soc. C.E. In death, as in life, these two friends were not far apart in time or in circumstances. Both were stricken as they prepared to attend engineering meetings in which they were intensely interested. It happens that Mr. Eddy was co-author of the Society's memoir for Mr. Gregory. This, typically, was one of the last of his continuous services over a period of many years.

So great were his contributions to the welfare of the Society that it is hard to pick out any single example. But perhaps his connection with the early days of CIVIL ENGINEERING may be considered typical. At that time he was chairman of the Society's Committee on Publications. He was not one to jump at conclusions quickly, and so his advocacy of the new publication for the Society was reached only after long study and deliberation. However, once he had decided in favor of the plan his confidence and loyalty never wavered. He was one of the most enthusiastic proponents of the new publication and was always interested in its problems and development.

Engineers showed their esteem for Mr. Eddy and his efforts to advance the profession by the large number of honors bestowed upon him. At various times he served as head of the Boston Society of Civil Engineers, and as vice-president of the American Institute of Consulting Engineers. He was recipient of an honorary doctorate from his alma mater. As it happened, his trip to Montreal was for the purpose of receiving international recognition in the form of honorary membership in the Engineering Institute of Canada, scheduled for a later hour of the day on which he died. His services to the Society were especially notable; no member could have been more useful or faithful. Since 1928 he had given six full and productive years to the work of the Board of Direction, only last January completing his term as Past-President.

His character was noble, his counsel wise, his friendship true. Few engineers will leave as deep an impression on their generation as Harrison P. Eddy.

Journalism Awards and Society Publicity

THE MOST coveted journalism award of the year for American newspaper reporters is the Pulitzer Prize. This year, it has been announced, the prize for reporting, which carries with it a cash award of $1,000, is being shared by five reporters.

Of interest to members is the fact that, during the past year or more, four out of the five prize winners have been in active cooperation with the Society's publicity department and have written stories concerning Society activities or civil engineering in general. The four who have included such reports in their year's work are Howard W. Blakeslee, New York, science editor, Associated Press; David Dietz, Cleveland, science editor, Scripps-Howard Newspapers; John J. O'Neill, New York, science editor, *New York Herald Tribune;* and William Laurence, New York, science reporter, *New York Times.*

New York College Establishes Student Chapter Prize

THE DAM CLUB, honor society of graduate civil engineers at the College of the City of New York, has recently announced the establishment of a prize to be awarded to undergraduate students in the memory of the late Prof. F. O. X. McLoughlin, M. Am. Soc. C.E. To be awarded first in the spring of 1938, this prize will consist of the initiation fee to the Society when the winner applies for Junior Membership.

During his lifetime, Professor McLoughlin made a similar award annually to a student selected as the most deserving member of the Student Chapter.

The new award will be made to that member of the Student Chapter at the College of the City of New York whose treatise is judged to be the best in competition. The papers may be on any topic of civil engineering interest. They are to be of such length as to permit of presentation in not more than twenty minutes. They will be judged on originality, interest, engineering accuracy, and method of presentation. Papers are to be in the hands of the committee by February 15, 1938.

Treat in Store for Boston Meeting

IT WILL BE welcome news that active preparations are under way by an energetic committee of the Northeastern Section to ensure a valuable Society meeting for next October. A number of interesting and attractive details are in preparation.

Outstanding among the technical features is the first session of the new Soil Mechanics and Foundations Division to be held at a Society Meeting. Other items of a more general character include a talk by Dr. Walter Gropius, eminent European architect with a reputation in many countries, who will discuss certain relations of engineers and architects; a joint meeting under the sponsorship of the Engineering Institute of Canada; and student gatherings of particular interest to colleges in the area. Special programs proposed for six of the Society's Divisions will round out the technical program.

In addition to these attractions, an unusually fine group of social events and excursions is being planned. Many visiting members are expected to take advantage of this opportunity to see historic and scenic New England under unusually favorable circumstances.

The meeting will begin Wednesday, October 6. More detailed information will be available in succeeding issues, and the official program will appear in the September number.

Early Presidents of the Society

XVI. HENRY FLAD, 1824–1898

President of the Society, 1886

It is encouraging to note the increasing interest of readers in supplying photographs and personal anecdotes for this series of sketches. Such cooperation is necessary for the preparation of informative, accurate, and readable articles, and is sincerely appreciated by the editors. The subjects of the next three installments will be William Ezra Worthen, Thomas Coltrin Keefer, and Max Joseph Becker.

HENRY FLAD was one of many men of rare ability for whose presence in America we are indebted to the Republican Revolution of 1848–1849 in Germany. He was born on July 30, 1824, in the Grand Duchy of Baden, near Heidelberg. After passing through the preparatory schools of Speyer, young Henry entered the University of Munich, in Bavaria, where he took the polytechnic course, graduating in 1846. At twenty-two years of age, he was given a position in the engineering service of the Bavarian Government, his first employment being on works for the improvement of the river Rhine.

HENRY FLAD
Sixteenth President of the Society

The years which immediately followed were years of great political commotion throughout Europe. Encouraged by the success of the revolution in France, the longings of the German people for a freer and more united government found such vigorous expression that the princes of the nany petty states into which Germany was divided acceded to the convocation of a National Assembly, or Parliament. Unfortunately, the deliberations of this assembly showed so little ability to unite in any workable plan that the ardor of the more conservative classes began to cool. The princes seized their opportunity to reassert themselves, and repudiated the authority of the Parliament.

In Southern Germany, the champions of the Parliament took up arms in its behalf. Flad, then in his twenty-fifth year, joined the Parliamentary army as a captain of engineers. Fortune, however, was against them, and, after several engagements, the Parliamentary army was driven into Switzerland, and disbanded. Meanwhile, its leaders were placed under the ban, and Flad, with many others, was sentenced to death.

Under these circumstances he took passage for the United States, and, in the autumn of 1849, landed in New York. It will be recalled that Albert Fink, his compatriot, had made the crossing just a year earlier, for similar reasons.

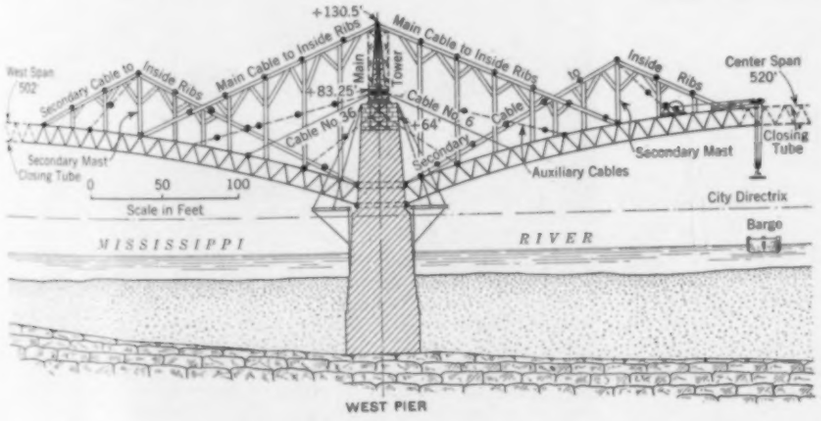
Flad's first employment, after his landing, was as a draftsman in an architect's office. It was not long, however, before he entered the engineering service of the New York and Erie Railroad, then under construction, his headquarters being at Dunkirk, N.Y., at the extreme western end of the road. In 1852 he became a resident engineer on the construction of the Ohio and Mississippi Railroad from Cincinnati to St. Louis (this line in 1893 became a part of the Baltimore and Ohio system).

Upon the opening of this line—the first to reach St. Louis from the East —in 1854, Flad went to Missouri as a resident engineer on the Iron Mountain Railroad (now a part of the Missouri Pacific). After its completion to Pilot Knob, where for a number of years it ended, he became land and tie agent of the railroad company, with headquarters at Arcadia, Mo.

Upon the outbreak of the Civil War, he enlisted as a private soldier in the U.S. Reserve Corps. A few weeks later "The Engineer Regiment of the West" was organized by Col. J. W. Bissell, and Flad was made Captain of Company B. In August 1861, he was detailed for service in the construction of fortifications at Cape Girardeau, Mo., where he remained for several months. Later in the year, he served as a staff officer under General Pope through the campaign of New Madrid and Point Pleasant, and at the taking of Island Number Ten. He was with his regiment at Fort Pillow and Pittsburg Landing, and during the operations before Corinth. During the summer of 1862, he was engaged in repairing the Mobile and Ohio Railroad, in building forts at Corinth, and in repairing the Mississippi Central Railroad. He was also engaged in Grant's advance on Grenada. In 1863, he was employed in engineering work at Young's Point, Baxter Bayou, Lake Providence, and Bayou Macon. Later he had charge of the repairs of the Memphis and Charleston Railroad at Memphis, Grand Junction, Jackson, and Columbus, and in the fall was with General Sherman, at Cherokee, Bear Creek, and Iuka, in northern Mississippi.

Meanwhile, he had been promoted to the rank of colonel, and on January 1, 1864, at Nashville, Tenn., he was transferred to the First Regiment of Engineers, Missouri Volunteers. During the following summer he was engaged in completing the Nashville and Northwestern Railroad from Nashville to Johnsonville, and in constructing defensive works. His last work was the construction of a new line of fortifications at Atlanta.

In November 1864, the term of enlistment of seven companies expired, and as the command of the remaining five companies, by army regulations, devolved upon the lieutenant-colonel, Flad was mustered out of service. He had served three years and six months constantly in the field, without more than a week's leave of absence, and without once having been sick or wounded.



A DETAIL OF THE ERECTION SCHEME, ILLINOIS AND ST. LOUIS BRIDGE
This Bold Plan, Which Eliminated the Use of Falsework, Was the Work of Flad

He returned to St. Louis and began to look around for employment in his profession. In a short time the agitation for an improved water supply for St. Louis resulted in a state law authorizing the appointment of a Board of Water Commissioners, charged with the duty of making surveys and plans and constructing a new system of water works for the city. Soon after the organization of the new board, in the spring of 1865, James P. Kirkwood was appointed chief engineer, and Henry Flad, chief assistant engineer.

By the end of the year a plan was presented for new works with intake, settling basins, and filter beds at the Chain of Rocks, and a distributing reservoir on what was then

known as Rinkel's Hill, on Easton Avenue, near the present city limits. This plan received the approval of the Board of Water Commissioners and, as subsequent experience has abundantly proved, was undoubtedly the best. But besides running counter to some private interests, it involved such a large outlay and such a radical departure from the old plan that it encountered overwhelming disapproval on the part of many leading citizens, as well as the city authorities. The opposition finally became so great that the Water Commissioners were called upon by the City Council to resign. In July 1866, a new board, committed to a new plan, was appointed. Meanwhile, Kirkwood had been commissioned to go to Europe to study the subject of filtration, and Colonel Flad was left as acting chief engineer. In December 1866, a revised plan, with intake and settling basin at Bissel's Point and a distributing reservoir on Compton Hill, was presented. This design was adopted substantially without change.

THE YOUNG REPUBLICAN: HENRY FLAD AT 24

When the German Revolution Failed a Year Later, Flad Was Sentenced to Death as a Leader of the Parliamentary Army

Early in the following year a new board was appointed with Colonel Flad as one of its three members. This position he held continuously by reappointment for eight years, during which time the new water works were completed, and put into service.

While he was still acting as assistant engineer to Mr. Kirkwood, Flad made the acquaintance of James B. Eads, who was at that time engaged upon plans for gun carriages and turrets. The rooms occupied by the Water Board being larger than they then needed, Eads, upon his request, had been granted space in which to place a draftsman at work. This was followed by frequent discussions between the two men upon engineering questions, which led to a mutual recognition of each other's abilities and laid the foundation of a life-long friendship. When, therefore, in 1868, Captain Eads, as chief promoter as well as chief engineer, was ready to begin constructing the great bridge over the Mississippi River at St. Louis, he tendered the position of chief assistant engineer to Flad. The duties of the latter as member of the Board of Water Commissioners did not require all his time, so the opportunity was gladly accepted. He retained his connection with the great enterprise until its completion in 1874; and during a part of the time, while Eads was in England, he served as chief engineer with full authority.

Eads was an engineer of marked natural ability and sound judgment, though he lacked technical training. He knew his own limitations and was ever willing to share honors with his associates and assistants. In 1874 he wrote to Flad as follows: "I should be violating my sense of justice and self-respect, were I not, unsolicited, to formally express to you my acknowledgment of the fact that the success which has attended my labors in the design and construction of the Illinois and St. Louis Bridge, is largely due to the assistance I have received from you. Your higher and scientific culture, sound judgment, fertility of resource, and experience in office details. . . have sufficed to relieve my mind of much care, anxiety, and labor; and I want you and everyone else to know that I fully appreciate the important part you have performed in winning the generous commendation which the world accords to our labors."

Some of the boldest features of the project were in fact the work of Flad—for example, the method of erecting the superstructure without the use of falsework. This scheme was adopted only after many controversies. It consisted of supporting the arches, during erection, by cables passing over temporary towers built on the piers. Hydraulic jacks were used to adjust the elevation of the outstretched arms.

It was characteristic of Flad to be lax—or modest—about asking compensation for engineering services. When Eads returned from Europe and learned that the erectors had adopted his assistant's plan of erection, he inquired how much Flad had charged for his plan. "I made no charge," Flad replied, "but I suppose they will pay me something." Eads was astonished: "You should have charged them $25,000!" he exclaimed. But the bill was never rendered and, naturally enough, payment was never made.

In 1874 Flad, as chief engineer of the Forest Park Commissioners, planned and laid out the since famous park on St. Louis' west side. Two years later, when the new charter of the City of St. Louis was inaugurated, he was elected the first president of the newly constituted Board of Public Improvements. This office he held continuously for nearly fourteen years.

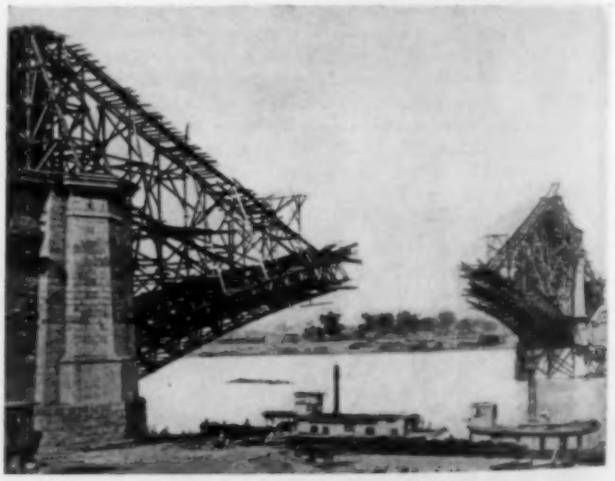
The problem to which the new Board addressed itself was that of taking the whole system of municipal public works out of the mire of politics, and placing it upon the basis of merit and fitness. Into this work Flad entered with characteristic zeal and a determination which nothing could shake. His efforts were crowned with entire success, so that during the whole period of his administration the Board over which he presided had the confidence of the whole community. Every citizen felt sure that in every department of the public works the city received a dollar's worth for every dollar spent, and in this respect St. Louis became a model for other cities.

In April 1890, he resigned his office to accept an appointment as member of the Mississippi River Commission, a position in which he remained until his death.

In November 1891, he was appointed by the Commission as one of a committee of two to prepare a project for the construction of a dredge boat to be used in deepening the Mississippi River over the bars in extreme low water—a problem in which his remarkable mechanical ingenuity found a fertile field. After a most careful study of the subject in all its bearings, plans were drawn for an experimental dredge, which was built under his personal supervision. While it was by no means perfect, its main features were found to meet the requirements so well that they have been embodied in the later dredges built by the Commission, and its construction marked the beginning of a new era in the history of river improvement.

Colonel Flad became a member of the American Society of Civil Engineers in 1871, and was President in 1886. He was also a charter member of the Engineers' Club of St. Louis, and for twelve years, from 1868 to 1880, was its president.

His death occurred suddenly from heart failure, June 20, 1898, at Pittsburgh, Pa., where he was visiting a life-long friend who, forty-nine years before, had come with him on the same ship to America.



ERECTING THE WEST AND CENTER ARCHES OF THE EADS BRIDGE

As an engineer, Colonel Flad was remarkable for his great fertility of invention; he was not limited by precedent, but looked instinctively for new and better methods. Nothing could exceed the interest with which he attacked a new problem, and he gave himself no rest until he had solved it. The solution once found, however, he would perhaps take out a patent, then forget it and turn to something new. Though his inventions were numerous and useful, to their introduction and utilization he gave but little

thought. It was work rather than its rewards for which he cared.

The manner in which he once disposed of a basic patent on air-brakes is a good illustration of this attitude. When the patent had but a few more years to run a stranger from the East came to see him, explaining that he had a client who wanted to patent an invention; that it conflicted with the Flad patent and that he was willing to pay a small sum for the latter in order to proceed. A few thousand dollars sufficed to close the deal. Not long thereafter one of Flad's friends overheard a conversation in a Pullman smoking compartment. The gentleman from the East was jubilantly explaining to a companion how he had acquired the patent. "Why," said he, "I was prepared to pay $50,000. It was for Westinghouse."

Among Flad's inventions may be mentioned an electrically operated air brake, a hydraulic elevator, a velocimeter, a rheobathometer (for taking deep-sea soundings), a testing machine, a cotton press, and a water filter. He also developed processes for the preservation of wood, and for measuring the heat in furnaces, the power of light, and the pressure of wind.

As a man Flad was characterized by unassuming modesty, perfect candor and simplicity, and single-minded subordination of personal to the public welfare. This evident and perfect integrity of purpose made his public service a legacy of incalculable value to his fellow citizens. His life was a demonstration of how honorable the public service can be made.

[The career of Edward Flad, M. Am. Soc. C.E., and son of the subject of this sketch, affords an interesting parallel to that of his father. In 1883 he became an assistant engineer in the water department of the city of St. Louis; a year after his father's death he was appointed water commissioner and became a member of the board of public improvements; and since 1924 he has been a member of the Mississippi River Commission. Mr. Flad's courtesy in reviewing the preliminary draft of this sketch, adding many of the details, and supplying the illustrations, is gratefully acknowledged. Parts of the text not supplied by Mr. Flad are largely abstracts of the Memoir published in TRANSACTIONS, Vol. 42.]

Herschel in Boston, Too

ONE OF THE most versatile of the eminent members of the engineering profession was Clemens Herschel, President of the Society in 1916. Famous throughout the world as an outstanding hydraulic engineer, he was also known for his early work in the structural field.

Recognition of this phase of his activity as applied to the Quinnipiac River Bridge in New Haven was noted in the June issue. This account has reminded Society members in Boston that Mr. Herschel was also prominent in that vicinity. F. A. Marston and J. B. Babcock, Members Am. Soc. C.E., have supplied the information given here.

Seventy years or so ago, Herschel designed a picturesque footbridge in the Boston Public Garden. A tablet on this bridge, placed a year ago by the Boston Society of Civil Engineers, notes the fact that this structure was opened June 1, 1867. Doubtless hundreds of thousands of people have crossed this bridge—not to mention other thousands who have passed underneath it in the famous "swan boats" as shown in the accompanying view—without realizing until now the historic nature of its construction.

BOSTON PUBLIC GARDEN FOOTBRIDGE
"Swan Boats" Appear at Right-Hand End

An article published in the July 1936 issue of the *Journal of the Boston Society of Civil Engineers* gives some of the details of its history and includes the accompanying photograph. The eye-bar chains were not merely decorations; originally they were used for structural purposes. With increasing loadings, however, strengthening became necessary, and the resulting structural changes have relieved the suspension action. At the same time, the graceful appearance has been maintained.

This historic bridge will not be so far from Society headquarters for the forthcoming Fall Meeting in Boston next October. Doubtless many will take advantage of this opportunity to investigate it for themselves.

New Postage Machine to Publicize Meeting

SOME 14 years ago, the Society was numbered among the first users of the postage meter machine, a mailing device that eliminates postage stamps and speeds the delivery of mail from the post office to its destination. In 1937, the Society is the first membership association in New York to adopt the latest model of this office appliance. Any postage denomination from a half-cent up to ten dollars is obtained by a single impression and in addition to imprinting the postage and the date of mailing, the envelope is sealed and made ready for delivery to the post office, all in one operation.

Annual Convention
DETROIT
July Twenty-First to Twenty-Fourth

This new model, however, gives the Society an opportunity to capitalize on a recent additional development in this machine, which permits the printing of an advertising slogan or a convention date on the mailing envelope. The Society will utilize this space to remind its members of approaching meetings and dates. It is expected that this notice, together with the regular announcements and program appearing in the pages of CIVIL ENGINEERING, will increase the interest of members planning to attend meetings and will also serve as a convenient reminder of the approaching date.

The accompanying illustration shows the die to be used in connection with the Annual Convention, at Detroit, Mich., July 21–24, 1937

Engineers' Council Publishes Engineering Bibliographies

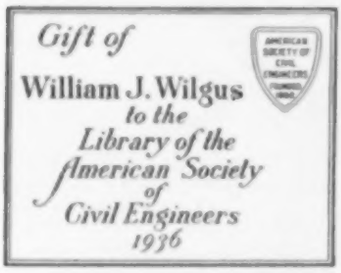
OF SPECIAL INTEREST to young engineers who wish to continue their studies and, perhaps, start building their own private libraries is the "Selected Bibliography of Engineering Subjects," just published by the Engineers' Council for Professional Development. The bibliography consists o a list of books, mostly of college grade, with annotations to indicate the nature and depth of subject matter. It is presented in five sections, Section II being devoted to aeronautical and civil engineering. The latter division lists some 150 titles.

Other sections are: I, Mathematics, Mechanics, and Physics; III, Chemical and Industrial Engineering; IV, Electrical and Mechanical Engineering; and V, Metallurgical and Mining Engineering. Single copies of any section can be obtained at a cost of 10 cents each from the office of the Secretary of the Engineers' Council for Professional Development, 29 West 39th Street, New York, N.Y. The price in lots of 50 or more (assorted, if desired) is 5 cents each.

These compilations are the work of the Council's Committee on Professional Training. They will undergo revision from time to time in order to improve the present lists and to include notable future publications.

Wilgus Gives Large Part of Private Library to Society

WILLIAM J. WILGUS, Hon. M. Am. Soc. C.E., has donated practically his entire professional library—a collection of more than 1,300 volumes, to public use. The Society and the New York City Public Library share the gift, the latter receiving material on military subjects and New York City projects, and the former receiving the general engineering works and data on non-local projects.



BOOK PLATE SPECIALLY PREPARED FOR THE WILGUS COLLECTION

Colonel Wilgus's collection has been amassed over a half-century of practice, and in addition to rare and important texts and other printed material contains a wealth of manuscripts and unpublished reports on important works in all parts of the country. Railways, being his primary interest, are of course best represented; other large groups of volumes include "ports and waterways," "general engineering," "civic problems," "tunnels," and "valuation."

Of special interest, perhaps, are the manuscript reports. Permission for their release required an extensive correspondence between Colonel Wilgus and the various clients involved. The quality of this material may be judged by that of the published works of the donor—he has for years contributed liberally to the technical press and has received both the Thomas Fitch Rowland Prize of the Society and the Telford Gold Medal of the Institution of Civil Engineers (Great Britain).

The Society's share of Colonel Wilgus's gift will soon take its place on the shelves of the Engineering Societies Library, at 29 West 39th Street, New York, N.Y. Each volume will be marked with a special book plate prepared by the Society to commemorate the donation.

Suggested Letter Symbols for Mechanics of Solid Bodies

UNDER THE AUSPICES of the American Standards Association, and with representation from all interested organizations, including the Society, the sectional Committee on Standard Letter Symbols for Mechanics of Solid Bodies met in New York, N.Y., on April 29, 1937, to receive preliminary reports from its subcommittees. Two of these submitted tentative lists for criticism. A list of standard letter symbols for the mechanics of solid bodies is presented herewith.

TENTATIVE LIST OF SYMBOLS FOR MECHANICS OF SOLID BODIES

ITEM	SYMBOL
Acceleration, angular	α
Acceleration, due to gravity	g
Acceleration, linear	a
Amplitude (vibration)	A‡
Angular distance, angle	θ
Angular velocity	ω
Area	A
Breadth (width)	b
Circular frequency ($2\pi f$)	ω or p
Coefficient of sliding friction	f or μ
Coefficient of temperature expansion	α
Constants	C
Coordinates, rectangular	x, y, z
Coordinates, polar	r, θ
Curvature, radius of	r or R*
Damping factor (velocity)	c
Depth (same as height)	h
Density (mass)	ρ
Density (weight)	γ
Diameter	d or D*
Distance, linear (arc length)	s
Eccentricity of application of load	e
Efficiency	η or e
Elasticity, modulus of	E
Elongation, unit (same as strain, unit normal)	ϵ
Elongation, total	δ or e
Energy (kinetic)	T
Energy (potential)	U
Factor of safety	n
Force or concentrated load	P or F
Frequency (harmonic motion)	f
Gyration, radius of	k
Height, depth, or thickness	h
Inertia, rectangular moment of (area)	I
Inertia, polar moment of (area)	J
Inertia, moment of (mass)	I
Length	L or l*
Load per unit distance	w or q
Load, total	P or W
Mass	m
Moment of force, including bending moment	M
Modulus of elasticity in shear	G
Neutral axis, distance to extreme fiber	c
Number: also number revolutions per unit time	n or N*
Period (harmonic motion)	T or t§
Phase angle (vibration)	ϕ or α
Poisson's ratio	μ
Pressure per unit of area	p
Radius	r or R*
Section modulus	Z
Shear, total in beam section	V
Spring constant (load per unit deflection)	k
Statical moment of area	Q
Strain, unit normal (same as elongation, unit)	ϵ
Strain, unit shear	γ
Stress, unit normal	σ or S or s
Stress, unit shear	t or S_s or s_s
Stress concentration factor	K
Temperature	t or θ†
Thickness (same as height)	h
Time	t
Torque	M or T
Velocity, linear	v
Volume	V
Width (same as breadth)	b
Weight	W
Work	W or U

The Committee on Standard Letter Symbols for Mechanics of Solid Bodies consists of the following: Prof. J. P. den Hartog, Harvard University; Prof. L. S. Jakobsen, Leland Stanford University; Prof. J. M. Lessells, Massachusetts Institute of Technology; Prof. G. H. McCullough, Worcester Polytechnic Institute; Dr. J. L. Maulbetsch, Timken Bearing Company; Prof. E. R. Maurer, University of Wisconsin; Dr. A. Nadai, Westinghouse Research Laboratories; Prof. F. B. Seely, University of Illinois; Prof. S. Timoshenko, Leland Stanford University; R. W. Vose, Jun. Am. Soc. C.E., Massachusetts Institute of Technology; H. M. Westergaard, M. Am. Soc. C.E., professor of civil engineering, Harvard University; Prof. B. M. Woods, University of California; and R. A. Peterson, Research Laboratories, Westinghouse Manufacturing Company, East Pittsburgh, Pa., chairman.

All those who have suggestions which they would like to see incorporated in the final standard list should communicate directly with Mr. Peterson. In addition to the foregoing symbols, a list of standard symbols on structural analysis is being prepared by another subcommittee under the chairmanship of Albert Haertlein, M. Am. Soc. C.E.

NOTE: Subscript usage not included in table. For example, the symbol for stress may be used in the following manner: σ_x, σ_y, σ_z for directional notation; σ_0, σ_v for steady and variable stress, respectively; σ_u for ultimate strength, σ_e for endurance limit, etc.

* Given in order of preference.

† Use θ for temperature in cases where both time and temperature are involved.

‡ Also subscript notation, such as x_0, y_0.

§ Use t for period in cases where both kinetic energy and period are involved.

American Engineering Council

The Washington Embassy for Engineers, the National Representative of a Large Number of National, State and Local Engineering Societies Located in 40 States

REORGANIZATION OF GOVERNMENT BUREAUS

FOUR BILLS carrying the principal points in the President's reorganization program are scheduled for this session of Congress, but it is doubted that any of them can pass under present circumstances. Even if departments of public work and social welfare should be established, Congress is not believed to be in a mood to delegate authority to the President over such important "arms" of government service as the comptroller general's office, the Interstate Commerce Commission, federal trade, communications, or power commissions, or willing to relinquish control over the disposition of public works appropriations and authority.

American Engineering Council has made its files available to both the President's committee on administrative management and the select committee on the investigation of executive agencies, and has offered its services to the joint committee on government reorganization. Each of the committees has studied Council's recommendation for the centralization of all public works under one qualified head. None of the findings of the committees have been announced, but all three committees are believed to have urged the creation of a public works department.

The report of the Upstream Engineering Conference entitled *Headwaters Control and Use*, brings together much current knowledge regarding the conservation and control of surface water from raindrop to river stage. Of most importance, however, are the recommendations made by President Roosevelt on May 12 in a letter transmitting the findings of the conference to Congress The outstanding recommendation reads: "With respect to some problems, drainage basins must be treated as a whole, both headwaters and main channel of any river system being brought into an integrated program of regulation." *Headwaters Control and Use* is a large volume, and only a limited number of copies are available, but it is understood that a few copies are available for distribution by the Soil Conservation Service, 261 Constitution Avenue, N.W., Washington, D.C. Other copies may be obtained at 60 cents each from the Superintendent of Documents, U. S. Printing Office, Washington, D.C.

After a series of addresses and discussions at the April 1937 meeting of the National Rivers and Harbors Conference, it was resolved that "ample funds should be provided at once to construct flood-control projects already authorized by Congress . . . ." Two diametrically opposite plans for water resources development received emphasis. The first is exemplified by the Tennessee Valley Authority and the recent legislation providing for a series of similar projects throughout the country. The second plan contemplates the coordination of federal, state, and local agencies according to the recommendations of the National Resources Committee in the development of basin plans and programs for the various phases of water use and control, including navigation, water power, municipal and industrial water supply, sanitation, irrigation, drainage, soil conservation, and biological and recreational uses. Council's present attitude favors the plan of coordination, but Council will be glad to have opinions from individual engineers and member organizations on these questions.

IS MAPPING AN ECONOMY MEASURE?

In spite of the fact that all engineers who have worked with and without maps are certain that vast economies can be secured in engineering operations if a knowledge of the terrain is available, mapping has not been officially accepted as an economy measure. In any event, the economy program recently announced by the President does not include the request to Congress for $5,000,000 recommended by Secretary Ickes for putting the basic mapping plan into effect.

With the valuable assistance of Dr. William Bowie, Council's surveys and maps committee and the many advocates of adequate basic maps for the United States have crystalized much sentiment into conviction in favor of inaugurating a real mapping program during the fiscal year beginning July 1, 1937. Many resolutions have been passed by engineering societies and by planning and scientific groups endorsing the mapping program, and it is a reasonable certainty that every congressman and senator has been informed by his constituents that mapping would be an advantage to his state.

Of the 3,026,789 sq miles of United States territory, exclusive of Alaska, less than half has been topographically mapped, and of this some 741,000 sq miles were mapped from 40 to 90 years ago by methods and on scales which do not serve present requirements. The U. S. Coast and Geodetic Survey has completed approximately 67,000 miles of triangulation and more than 265,000 miles of levels in the United States, but engineers know that that is only a small percentage of what should be done.

Observing its fourth anniversary, the Public Works Administration lays claim to a long list of achievements, in cooperation with local communities, in a highly diversified program of emergency construction. As the need for "made public work" is eliminated and engineers consider what has been learned about the value of such a public works program, every effort should be made to preserve these lessons so that if ever again the occasion arises, the nation will be in a more favorable position to undertake a program of useful federal and community projects.

Works Progress Administration news has to do chiefly with relief work on mineral-survey projects in western states, and according to WPA procedure No. 37, dated March 17, 1937, the contributions made by sponsors may take the form of cash paid for the services of consulting engineers employed to prepare plans for and supervise the work on projects involving mineral surveys. Mineral-survey projects may be approved and partially financed by the Works Progress Administration in any state where sponsors will pay for engineering and furnish tools and material, provided sufficient relief labor is available to complete the projects.

The U. S. Bureau of Public Roads and the Soil Conservation Service of the U. S. Department of Agriculture have announced the beginning of actual operations to protect highway cuts and fills, highway ditches, and drainage structures in Alabama, Arizona, Arkansas, Georgia, Idaho, Illinois, Indiana, Maryland, Mississippi, North Carolina, Ohio, Oregon, South Carolina, Texas, Utah, Virginia, Washington, West Virginia, and Wisconsin. Under present plans, the Soil Conservation Service will furnish technical supervision, labor, and planting materials where the state will supply construction material and equipment, and agree to maintain the control work for five years after the planting or construction is done.

PUBLIC SERVICE AND THE ENGINEER

Engineering employment by government agencies in Washington is somewhat disturbed by the threats of both Congress and the administration to actually apply economy measures. The President has ordered all departments, administrations, and commissions, including the Bureau of the Budget, to materially reduce current expenditures and to limit future operations to be budgeted within the national income. Congress seems to have accepted the President's advice, and to have set itself to the task of reducing federal expenditures. A distressingly large number of competent engineers are leaving government work with its uncertainties and meager compensation for the increasingly attractive private life. In recognition of operating difficulties likely to develop as more of the better engineers return to private employment and practice, the Civil Service Commission is planning to conduct an unassembled examination for engineers of the several grades of a dozen branches of engineering at an early date.

Council's staff has just completed a report for the American Society of Civil Engineers which includes a comprehensive survey of government agencies employing engineers on a contract, per diem, or percentage fee basis. As a result more than thirty important agencies are listed in the report, with references to the laws or rulings governing procedure in each bureau and the fees paid or the method for determining fees. The extent of the use of consulting engineering services is also indicated in many instances.

Since this report is believed to be the first review of a very complex situation which is of interest to almost all engineers in private practice, Council expects to mimeograph copies for all member engineering organizations as soon as the final draft has been approved by Council's committee on the engineer's economic status.

Washington, D.C.
June 1, 1937

News of Local Sections

CENTRAL OHIO SECTION

There were 40 present at a meeting of the Central Ohio Section, which took place in Zanesville, Ohio, on May 22. Following luncheon, which was served at the Zane Hotel, interesting talks were given by F. S. Taudy, captain, Corps of Engineers, U. S. Army, and executive officer of the Zanesville District; and G. H. Friend and C. C. Chambers, respectively chief of the engineering division and chief engineer of the Muskingum Watershed Conservancy District. Several reels of motion pictures, depicting the construction accomplishments of the Muskingum Conservancy District, were also shown. The members then took an inspection trip to the Willis Creek and Mohawk dams, both of which are practically completed.

COLORADO SECTION

The regular monthly dinner meeting of the Colorado Section took place on May 10, with 70 members present. During the business session the constitution of the Junior Association of the Colorado Section was presented and accepted by the Section. The Section's annual award of a student prize consisting of paid membership in the Society as a Junior was also made. An interesting talk by Charles W. Henderson, supervising engineer for the U. S. Bureau of Mines, concluded the evening. Mr. Henderson discussed the subject of mineral resources and described many of his experiences in the Bureau. On June 1 a regular meeting of the Junior Association of the Section was held. On this occasion arrangements were in charge of a program committee consisting of A. A. Futral, J. W. Cahoon, and R. T. Cass. The speaker was R. D. Brown, special agent in charge of the Denver office of the U. S. Department of Justice, who discussed the topic, "The True Cost of Crime."

DAYTON SECTION

There were 21 present at the regular monthly meeting of the Dayton Section, which was held at the Engineers' Club on May 17. After disposing of the business of the Section, the members enjoyed a motion picture covering the highlights of a trip from San Francisco to Australia. These were shown by James Leonard, of Adelaide, Australia.

DISTRICT OF COLUMBIA SECTION

More than 1,000 members and guests of the District of Columbia Section attended a meeting held on May 5 in the auditorium of the U. S. Department of Commerce in Washington, D.C. On this occasion C. F. Goodrich, chief engineer of the American Bridge Company, showed motion pictures and slides of the construction of the San Francisco–Oakland Bay Bridge.

GEORGIA SECTION

Members of the Georgia Section were guests of the Georgia School of Technology at a luncheon meeting held on April 12. There were 26 present on this occasion to hear C. D. Gibson, head of the department of geology at the school, speak on "Geology and the Civil Engineer." There were 31 present at a meeting of the Section held at the Atlanta Athletic Club on May 10. During the business session a resolution was passed, expressing the appreciation of the Section for the cooperation of certain members of the Georgia legislature in passing an engineers' registration law. An interesting talk on the effects of the law on the engineering profession was then given by T. Keith Legaré, who based his remarks on his experience as secretary of the South Carolina Registration Board.

INDIANA SECTION

On May 28 the Indiana Section held a dinner meeting in Indianapolis. The guests of honor were Dr. W. K. Hatt, of Purdue University; Prof. R. L. McCormick, of Rose Polytechnic Institute; and the Purdue winners of the 1937 student prizes awarded by the Section. Both Dr. Hatt and Professor McCormick are retiring after teaching for more than forty-five years. The feature of the occasion was a talk by Howard S. Morse, Director of the Society, who discussed his experiences on the Board of Direction. During the evening it was announced that a letter ballot on the question of affiliation with the recently formed Indiana Engineering Council was overwhelmingly in favor of such a move. There were 31 present.

ITHACA SECTION

On May 12 the Ithaca Section met in Willard Straight Hall on the campus of Cornell University. This meeting was held in honor of Samuel A. Greeley, senior member of the firm, Greeley and Hansen, consulting sanitary and hydraulic engineers of Chicago. A dinner preceded a short business session. Then the group adjourned to Sibley Hall to hear Mr. Greeley give an illustrated talk on the Buffalo sewage disposal project, for which his firm is acting as consultant. There were 26 present.

KANSAS STATE SECTION

A meeting of the Kansas State Section took place at Topeka on May 13, with the recipients of this year's student prizes as guests of honor. The attendance of 67 included 19 members of the University of Kansas Student Chapter and 16 members of the Chapter at Kansas State College. After a business session a film on the Colorado River Aqueduct was shown.

KENTUCKY SECTION

The Kentucky Section held its first meeting of the current year at the Seelbach Hotel in Louisville on March 16. About 20 members of the Section were present for dinner. Then H. S. Morse, Director of the Society and general manager of the Indianapolis Water Company, gave a short talk on the aims and activities of the Society. Later the meeting was adjourned in order to hold a joint session with the Engineers and Architects Club of Louisville. On this occasion the acting district engineer for the Louisville District of the U. S. Corps of Engineers spoke on the subject of "Ohio River Valley Floods and Their Control." On April 30 a number of the members of the Section were guests of the engineering college of the University of Kentucky, which was celebrating its fiftieth anniversary. During dinner an address was given by George H. Sager, Jr., state director of PWA, who discussed the PWA program in Kentucky.

LOS ANGELES SECTION

On May 12 the California Institute of Technology Student Chapter entertained 230 members and guests of the Los Angeles Section at an outdoor dinner on the campus of the Institute. Following dinner and a program of entertainment several speakers were heard. These included Louis C. Hill, President of the Society; Field Secretary Walter E. Jessup, who discussed the development of Student Chapters throughout the country; Thomas H. Morgan, chairman of the division of biology at the Institute, whose topic was "Biology in Relation to Engineering"; and Hunter Rouse, assistant professor of fluid mechanics at the Institute, who stressed the superiority of technical investigation of fluid problems over the empirical formulas that have been used for years. The hour preceding dinner was spent in inspecting the laboratories.

LOUISIANA SECTION

On April 27 the Louisiana Section held a luncheon in honor of Dr. William Bowie, who recently retired after many years of service with the U. S. Coast and Geodetic Survey. There were 30 present. The regular spring meeting of the Section took place at Louisiana State University in Baton Rouge on April 28, with approximately 150 members and guests present. An address on "The Reasons for State Planning and Its Purposes" was given by J. Lester White, chairman of the Louisiana State Planning Commission. Then Daniel W. Mead, Past-President of the Society, who was en route to his home after attending the San Antonio meeting, spoke on individualism and sound theory as a basis for engineering education.

METROPOLITAN SECTION

An interesting program was scheduled for the closing meeting of the Metropolitan Section, which took place in the Engineering

Societies Building in New York City on May 19. Leslie G. Holleran, retiring president of the Section, gave a talk on the functions and activities of the Metropolitan Section. He was followed by George T. Seabury, Secretary of the Society, who discussed the relationship of the Local Section to the Society. The Annual Effective Speaking Contest was then conducted under the auspices of the Junior Branch of the Section. The two prizes in this contest, now known as the William F. Reeves Memorial Prizes, were won by Benjamin P. Robinson, for his talk on noise abatement, and J. Edwin Ure, for his talk on technology and the consumer. The Section then awarded prizes to the outstanding senior in each of eight local Student Chapters. The election of officers for the coming year closed the meeting. The list is as follows: Harold W. Hudson, president; R. E. Bakenhus, vice-president; J. S. Langthorn, treasurer; and Joseph W. Barker, William Heyman, and Thorndike Saville, directors. At the close of the meeting refreshments were served to the 200 present.

NASHVILLE SECTION

The Nashville Section elected new officers at its meeting held on June 1. These are E. W. Bauman, president; W. A. Coolidge, vice-president; and L. R. Curry, Jr. secretary and treasurer. A report of the San Antonio meeting of the Society was then given by F. J. Lewis, who attended as delegate from the Section. There were 20 present.

NEW MEXICO SECTION

A regular meeting of the New Mexico Section took place at the University of New Mexico in Albuquerque on April 14. After a short business session Raymond A. Hill, Director of the Society, was introduced. Mr. Hill spoke on several matters of interest to the Section, including the matter of subsidizing Local Sections. The technical program consisted of a paper by C. V. Theis, associate geologist for the U. S. Geological Survey, whose topic was "Ground-Water Studies in the Middle Rio Grande Valley of New Mexico."

NORTH CAROLINA SECTION

Election of officers for the coming year took place at the meeting of the North Carolina Section, which was held in the Washington Duke Hotel in Durham, N. C., on May 8. The list is as follows: J. L. Becton, president; O. B. Bestor and G. H. Maurice, vice-presidents; and Harold C. Bird, secretary-treasurer.

NORTHEASTERN SECTION

There were 320 present at a meeting of the Northeastern Section held in the Eastman Auditorium of the Massachusetts Institute of Technology on May 5. The feature of the occasion was the presentation of a symposium on "Flood Control Plans for New England Rivers." The speakers appearing on this program were H. K. Barrows, professor of hydraulic engineering at the Institute; Mason J. Young, district engineer in the U. S. Engineer Office at Providence; and Hugh J. Casey, captain, Corps of Engineers, U. S. Army. A spirited discussion on the economic justification for the various flood control plans followed. A dinner preceded the meeting.

NORTHWESTERN SECTION

A joint dinner meeting of the Northwestern Section of the Society and the St. Paul Engineers' Society was held at the Town and Country Club in St. Paul on May 10. There were 46 present. A short talk on the San Francisco–Oakland Bay Bridge was given by an engineer connected with the Carnegie-Illinois Steel Company, after which motion pictures depicting the construction of the bridge were shown. There were 46 present.

PHILADELPHIA SECTION

The Junior Group of the Philadelphia Section was in charge of the May meeting, which was held at the Engineers' Club on the 19th. A. Harry Wagner, chairman of the Junior committee on arrangements, presided and introduced the speakers. These were L. A. Huber, chief of party for the New Jersey Geodetic Control Survey, who described the work being done in that state by the U. S. Coast and Geodetic Survey in conjunction with the state authorities; R. W. Thompson, Jr., who explained the methods of the U. S. Geological Survey in making measurements of stream flow in the state of New Jersey; Samuel T. Carpenter, instructor in civil engineering at Swarthmore College, who presented the plan of the Program of Professional Development, as it has been instituted by the Junior Group of the Section; and H. J. Engel, who gave a paper on "The Engineer and Society." In the latter talk Mr. Engel painted a vivid picture of present economic conditions and emphasized the fact that the technical professions should contribute to the solution of economic problems. A social hour followed this program. There were 35 present.

PORTLAND (ORE.) SECTION

The week-end of May 15 provided the Portland (Ore.) Section a full program of Society activities. On Saturday, the 15th, the members journeyed to Corvallis, where they held their annual joint meeting with the Oregon State College Student Chapter. Many went early enough to enjoy some of the events of "campus week-end," which were open to all. A feature of the technical session was the presentation of two of the prize-winning papers in the annual contest conducted by the Portland Section. A banquet followed the technical meeting. There were approximately 75 present. On Sunday W. E. Jessup, Field Secretary of the Society, was principal speaker at a breakfast given by the Student Chapter. He discussed the development of the Society. On Monday, at a luncheon meeting held in Portland Mr. Jessup again spoke, discussing Society affairs in general and Section problems in particular.

PROVIDENCE SECTION

At the annual meeting of the Providence Section, which took place on May 19, a resolution was passed, establishing two prizes to be given annually by the Section for the best papers presented in competition by senior class students at Rhode Island State College and Brown University. Officers for the coming year were also elected at this session, the list being as follows: William R. Benford, chairman; Frederick H. Paulson, vice-chairman; and Norman Bampton, secretary-treasurer.

SACRAMENTO SECTION

During May the Sacramento Section continued to enjoy weekly luncheon meetings. At the session held on the 4th, there were 50 present to hear Field Secretary Jessup speak. Mr. Jessup discussed the history, development, and objectives of the Local Sections as well as Society affairs in general. On May 11, S. D. Brothers, assistant traffic manager of Pan-American Airways, gave a brief history of the development of the airplane and the evolution of the present commercial airways system. There were 62 present. On May 18, J. B. Lillard, president of Sacramento Junior College, gave an interesting lecture on various tribes of Indians once native to the region. There were 128 at the meeting held on May 25. On this occasion the speaker was Franklin Thomas, director of the Metropolitan Water District of Southern California and professor of civil engineering at California Institute of Technology. Sound motion pictures and slides accompanied this lecture.

SAN DIEGO SECTION

An unusual program was enjoyed at the meeting of the San Diego Section held on April 22. After a short business session each of those present described some amusing or interesting experience connected with his career as a civil engineer. Among those who spoke were C. B. Sadler, Clayton Neil, J. Y. Jewett, H. A. Noble, Norman McLean, L. L. Mills, Paul Beermann, E. C. Kanters, and W. E. Capwell. On May 10 a special meeting of the Section was called in honor of Field Secretary Jessup, who spoke on various matters of interest to the Section. There were 14 present.

TACOMA SECTION

Several business matters were discussed at a meeting of the Tacoma Section held on March 8. The speaker on this occasion was R. G. Hennes, of the department of civil engineering at the University of Washington. At the session held on April 6 the speaker was Harry Livingston, of the DuPont Powder Company.

ITEMS OF INTEREST

Engineering Events in Brief

Civil Engineering for August

Among the articles scheduled for the August issue is one on irrigation in North China, by O. J. Todd, M. Am. Soc. C.E., consulting engineer. Ancient systems for irrigating certain bottom lands in the provinces of Ningsia, Suiyuan, Shansi, and Shensi are not utilized to any considerable degree today. Periods of prolonged drought seem to be occurring in these and other northwestern provinces with increasing frequency and with consequent famine and suffering among the people. During the past seven or eight years the various provincial governments, aided in some cases by famine-prevention agencies, have undertaken to develop larger irrigation projects and conserve more thoroughly available flow in the principal streams. Four of these projects are described by Mr. Todd. The construction methods employed will be of special interest to engineers as illustrating the contrast between labor conditions in America and in China.

The determination by means of wire-model analysis of stresses produced by the settlement of a multiple-frame structure is the subject of an article by Anders Bull, M. Am. Soc. C.E., assistant engineer, Board of Transportation, New York City. In dealing with the settlement of the carshed structure involved, mathematical analysis was found too extensive and cumbersome, while methods based on Maxwell's law of reciprocal deflections were not suitable. The method used avoids both these difficulties and is, at the same time, highly accurate. Two separate wire models were made, the first more simple in form than the second. Tests indicated that the simplification adopted for the first model gave unsafe results for settlement stresses although on the safe side when dealing with external loads.

The story of wood from the forest to the retail lumber pile is described in a third article scheduled for the August number, by Nelson C. Brown, of the New York State College of Forestry. The universal utilization of this material, the strongest in proportion to its weight available to man, makes a knowledge of its characteristics and methods of production important. From the first sawmill driven by wind, erected on Manhattan Island in 1623, the center of the lumber industry shifted to Maine, New York, Pennsylvania, and Michigan, later to the South, and since 1916 to the north Pacific coast, where the peak production was reached in 1926. The type of wood most in use has undergone a similar metamorphosis, from white pine to southern pine, and latterly to Douglas fir and southern pine.

If space permits, there will be included an article by L. W. Millard, bridge engineer, Michigan State Highway Department, on the design and construction of the Cooley steel bridge over the Manistee River in northwestern Michigan. A deck-truss steel structure, the bridge's two 125-ft cantilever arms, supporting a 50-ft suspended section, are tied to concrete abutments at the ends of two 125-ft anchor arms. The bridge was dedicated late in 1935 in honor of Mortimer E. Cooley, Honorary Member of the Society. In recognition of the designers' success in making the bridge well-proportioned and pleasing without superficial ornamentation, the structure was awarded first prize by the American Institute of Steel Construction as the most beautiful bridge of its class built in America during 1935.

Wise and Otherwise

During the past month Professor Abercrombie has interested himself in the activities of three widely varying types of animals—snails, flies, and amebas. The three problems which follow are taken from "The News," a publication of the Philadelphia Section. They can and should be solved mentally:

A snail is attempting to climb out of a well 20 ft deep. Starting at the bottom, he climbs up 5 ft the first day and slips back 4 ft during the night. This process is repeated each 24 hours. How many days will he require to reach the top?

Two automobiles 90 miles apart are traveling toward each other, the first at the rate of 40 miles per hour and the second at the rate of 20 miles per hour. A fly leaves the front bumper of the faster car and flies to the front bumper of the other at the rate of 70 miles per hour. Having reached this goal he flies back to the first bumper. The devoted insect continues to shuttle back and forth until crushed between the bumpers as the cars come together. Assuming that the fly's rate of speed does not vary and neglecting the time spent in stopping and turning, what is the total mileage he travels?

Seven amebas are disporting themselves in an otherwise empty glass. Being almost as well versed in mathematics as Professor Abercrombie himself, they multiply very rapidly—in fact, they double in number every 20 min. At the end of 40 min there are 28 amebas; at the end of one hour, 56 amebas; and so forth. In exactly 3 days the glass will be filled to the brim. How long will it be before the glass is half full?

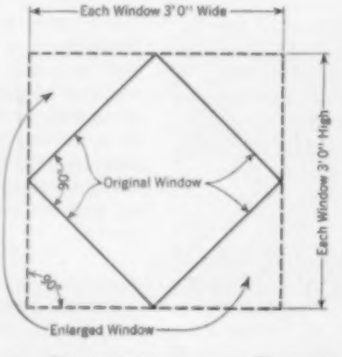


Fig. 1. Enlargement of Professor Abercrombie's Window

In the first problem published in June, Professor Abercrombie's square window, 3 ft wide and 3 ft high, was enlarged to double its original area while it still remained a perfect square 3 ft wide and 3 ft high. The solution will be evident from an inspection of Fig. 1, the areas of the windows being 4.5 and 9.0 sq ft, respectively.

The second problem consisted in performing the following literal subtraction:

$$\begin{array}{r} ABC \\ -CBA \\ \hline *** \end{array}$$

The remainder was to consist of the same three digits, arranged in a third order. (Through an error in printing, the asterisks appeared above the line in the June issue.) It is believed that the following demonstration is rigid, giving only one possible solution.

Since $ABC > CBA$, it follows that $A > C$, $C < A$, and the middle digit in the result must be 9. Considering now the digit on the right, $C + 10 - A = A$, B, or C, from which this numeral must be either A or B. If it is A, then

$$A = 5 + \frac{C}{2} \cdot \cdot \cdot \cdot \cdot \cdot \cdot \quad [1]$$

and if it is B, then

$$B = 10 + C - A \cdot \cdot \cdot \cdot \cdot \quad [2]$$

Similarly, considering the digit on the left, $-1 + A - C = A$, B, or C. From this, the numeral must be either B or C. If it is C, then

$$A = 2C + 1 \cdot \cdot \cdot \cdot \cdot \cdot \cdot \quad [3]$$

There are therefore three possibilities to be investigated—BCA, CBA, and CAB. The result cannot be BCA, since this would require $A < C$, C being 9.

The combination CBA is the same as the subtrahend, and is therefore ruled out. But if CBA were considered, B would be 9. Then from Eq. 1, $A = 8$, 7, or 6. From Eq. 3, A must be odd, that is, 7, and inserting this value in Eq. 1, $C = 4$. These values do not satisfy the conditions when substituted in the original problem, and therefore CBA is not the correct result.

The only remaining combination is CAB, where $A = 9$. From Eqs. 3 and 2, $C = 4$ and $B = 5$. These values satisfy the conditions of the problem, and are also the only ones which do so.

Suggestions for other problems for Professor Abercrombie's column, accompanied by solutions, may be addressed to the editor. Solutions should preferably be sent in separate enclosed envelopes.

Engineers During the French Revolution

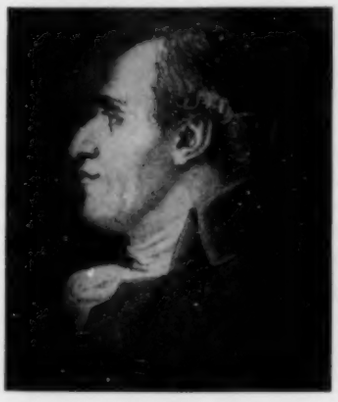
By RICHARD S. KIRBY, M. AM. SOC. C.E.
CHAIRMAN, DEPARTMENT OF ENGINEERING DRAWING, YALE UNIVERSITY, NEW HAVEN, CONN.

EVER SINCE a great leader of our profession urged it several years ago, American engineers have been peering anxiously around successive corners for something which is only now faintly emerging from the shadows. Opportunity for reflection has not been lacking. Perhaps at this time some of us may be cheered by turning our thoughts back a century and a half to the experiences of certain of our French confrères during times much more troublous and out of joint than those through which we have just passed. I refer to the period between 1792 and 1815.

GASPARD FRANÇOIS CLAIR MARIE RICHE DE PRONY
An Aristocrat Who Survived the Revolution

In the generation preceding the Revolution, French engineers, most of them trained in her great professional school, were the acknowledged leaders of the world in the construction of stone bridges, roads, canals, and harbors. Then came the guillotine, to which were sacrificed the lives of thousands of the best blood of France. It is interesting to inquire as to what happened to the outstanding French engineers of this disturbed period—men whose names and achievements are not altogether unknown to American engineers of our day.

The dean of French civil engineers, Jean Rodolphe Perronet, was past four score. He had for some time lived, a lone widower, in a little "pavilion" at the Place de la Concorde, dependent on governmental aid. He was still nominally head of both the *Corps d'Ingénieurs des Ponts et Chaussées* and the *Ecole des Ponts et Chaussées*, neither of which was much disturbed by the revolutionary movement. When 1793 brought gruesome scenes close to his door, he petitioned to be allowed to move into the country. Permission was granted, and he did move, returning after some months to Paris, like many another good Frenchman, only to die in his bed.



GASPARD MONGE, THE ORIGINATOR OF DESCRIPTIVE GEOMETRY

Antoine de Chézy, father Perronet's principal assistant, was in a worse plight. Until he was thirty, Chézy had trained for the priesthood. Brilliant in research, but physically frail and naturally shy and retiring, he had passed three score and ten and was shortly pensioned by the government. The pension unfortunately seems to have been paid in depreciated currency, and Chézy, doubtless weak and undernourished, came to the end of his resources. It is said that he had to contemplate selling the very hair out of his mattress. Finally, shortly before he died, friends came to his aid and gave him, for a few short months, the place left vacant by the retirement of Perronet's successor. Thus ended the life of the genius who by his researches gave hydraulicians one of their fundamental formulas, $V = C\sqrt{RS}$.

Perronet's other assistant, Prony (who later devised the dynamometer still called by his name) was less than half as old as Chézy—only 37 in 1792. He was of an aristocratic family, but no politician, and the government, recognizing his worth, put him in charge of what we should call a WPA project. This was nothing less than the preparation of new sets of logarithmic and trigonometric tables for the geodetic survey, the *Bureau du Cadastre*, dividing the circumference decimally, as everything was being divided in those days. The various tables were carried out to 14 and even 25 decimal places. To assist him, he had several of the foremost mathematicians and scientists of the day—among others, Laplace, of nebular hypothesis fame, and Legendre. But the bulk of the routine calculations fell on young men, almost boys—"perruquiers" or coiffeurs—who had lost their jobs when wigs and powder were proscribed by the revolutionary government; some of them could barely add and subtract. The 17 folio volumes were completed in duplicate manuscript form in about three years—and have been gathering dust on the shelves of the library at the Paris Observatory ever since. Prony stood at the head of his profession during the Napoleonic period and retained this prestige until his death.

MARC BRUNEL PERHAPS OWED HIS LIFE TO HIS DRAFTING SKILL
He Forged A Passport to Escape to America During the Revolution

Gaspard Monge, who should be well known to this generation of engineers as the originator of descriptive geometry, was an ardent revolutionist; at least he stood for all that was forward-looking and sane in the movement. Though of decidedly humble origin (his father was a pedler) he was then, in middle life, one of the country's beloved and trusted scientists. After several years of invaluable help to the sorely pressed government in the manufacture of cannon and other munitions, he became the principal founder and head of the great school which grew out of the

PERRONET'S ARCH BRIDGE IN PARIS (FROM AN EARLY NINETEENTH CENTURY PRINT)
Originally Intended to Be Named for Louis XVI, This Structure Was Later Called the Pont de la Revolution, and Finally, in Quieter Days, the Pont de la Concorde

Revolution, the Ecole Polytechnique. Throughout Napoleon's regime, Monge retained his place near the top of a galaxy of scientiest, only to lose it after Waterloo.

Few engineers of the period were at all politically minded, but there was at least one who could not withhold his bursts of enthusiasm for the old regime. He was Marc Isambard Brunel, then a budding genius, whose lack of restraint eventually obliged him to flee the country. Unfortunately he lost his passport, but, skilled as a draftsman, he made a new one which answered the purpose, and set sail with a moderately clear conscience for America. Young Brunel spent some years in the wilds of northern New York, where he made surveys which eventually led up to our Champlain Canal. Later he took up his residence in New York City and seems to have been able to turn his hand to anything in the field of civil and military engineering, architecture, and mechanical invention. When war with his mother country appeared to be imminent at the close of the century, he sailed for England, and lived to inscribe his name high on the roll of British engineers and inventors and to become the father of an even more famous engineer, Isambard Kingdom Brunel.

There were of course others, destined to become famous engineers, who were too young to be much affected by the political events of 1792. Simon Bernard was then in his 'teens. Later, however, he did serve on Napoleon's staff. After Waterloo he came to America, where he did much to build up our young Corps of Engineers and, among other substantial achievements designed Fortress Monroe.

Louis Joseph Vicat, who later made the classic pioneer researches into the nature of cement, was barely six years old in 1792, and younger still was Augustin Jean Fresnel, discoverer of polarized light. Fresnel's political troubles came on him during the eventful "hundred days" when, it is said, he just had to keep out of Napoleon's way.

Finally, there was Claude Crozet, who was but an infant in the days of the Reign of Terror. In 1815, as an artillery officer, he followed—or probably preceded—Napoleon to Moscow, and was captured in the retreat. He came to America in 1816 to become our first professor of civil engineering.

Brief Notes from Here and There

IN "Something To Think About," CIVIL ENGINEERING presents this month an editorial on arbitration. The subject may be pursued further in the April issue of the *Arbitration Journal*, a new quarterly published by the American Arbitration Association, 8 West 40th St., New York City. The issue features a symposium on "Arbitration in Real Estate and Construction." Individual papers discuss particular applications to the building trades, to engineering contracts, and to public construction contracts.

THE nominating committee of the American Society of Mechanical Engineers has presented the following nominees for office in that organization for the year 1938: For president, H. N. Davis, president of Stevens Institute of Technology, Hoboken, N.J.; for vice-presidents, F. O. Hoagland of Hartford, Conn., B. M. Brigman of Louisville, Ky., Harte Cooke of Auburn, N.Y., W. H. McBryde of San Francisco, Calif., and L. W. Wallace of Chicago; for managers, Carl Bausch of Rochester, N.Y., S. B. Earle of Clemson College, S.C., and F. H. Prouty of Denver, Colo.

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HYDRAULICIANS will be interested to learn that the Société Hydrotechnique of France is publishing a bimonthly journal containing reports of current hydraulic practice and development of theory in that country. The publication, *Revue Générale de l'Hydraulique*, is now in its third year, but copies have only recently been sent to the United States. Inquiries should be directed to the publishers at 116 Avenue d'Orléans, Paris (14), France.

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THE LAST of a series of three volumes summarizing data on the construction industry has recently been issued by the Bureau of the Census, Department of Commerce. This volume gives figures for work performed in 1935 in five general types of construction (one- and two-family house, other residential, other building, highway, and heavy construction), each of which is further broken down into new construction and repairs, private and public construction. The report also analyzes the work performed according to its location, and presents comparative figures for 1929 and 1935. The most important type of construction, building other than residential, amounted to 32 per cent of the total, which in 1935 represented about 40 per cent of the 1929 figure. Construction by government agencies and others than contractors is not included.

Engineers Awarded Honorary Degrees

EACH YEAR at commencement time honorary degrees are awarded to certain engineers who have made outstanding contributions to the profession. Several members of the Society are among those thus honored this year. The following list of engineers who have received such awards has reached Headquarters. Doubtless there are others of whom the Society has not yet heard.

RALPH H. CHAMBERS, M. Am. Soc. C.E., Doctor of Engineering, Rensselaer Polytechnic Institute.

W. K. HATT, M. Am. Soc. C.E., Doctor of Laws, University of New Brunswick.

E. R. NEEDLES, M. Am. Soc. C.E., Doctor of Engineering, University of Missouri.

CHARLES H. PURCELL, Assoc. M. Am. Soc. C.E., Doctor of Laws, University of California.

HENRY E. RIGGS, M. Am. Soc. C.E., Doctor of Engineering, University of Michigan.

ROBERT L. SACKETT, M. Am. Soc. C.E., Doctor of Engineering, University of Michigan.

OLE SINGSTAD, M. Am. Soc. C.E., Doctor of Engineering, New York University.

HOMER R. STANFORD, M. Am. Soc. C. E., Doctor of Engineering, Rensselaer Polytechnic Institute.

JOHN F. STEVENS, M. Am. Soc. C.E., Doctor of Engineering, Polytechnic Institute of Brooklyn.

NEWS OF ENGINEERS

Personal Items About Society Members

WILLIAM BOWIE, who recently retired after long service as chief of the Division of Geodesy of the U. S. Coast and Geodetic Survey, has been awarded one of the 1937 medals of the Franklin Institute of Pennsylvania. The citation accompanying his award read, "In consideration of his contributions to the science of geodesy, particularly with reference to the theory of isostasy, the applications of which he has extended to problems in general geophysics and geology.

H. S. HURLBURT is now resident engineer for the Central Ohio Light and Power Company at Bluffton, Ohio. He was previously chief of party for the Mason-Walsh-Atkinson-Kier Company on the construction of Coulee Dam at Mason City, Wash.

C. R. LOGAN has resigned as resident engineer inspector for the Public Works Administration at Lexington, Ky., to become chief engineer on the penal and eleemosynary institution building program now being started by the state of Kentucky. His headquarters are at Frankfort, Ky.

H. N. RODENBAUGH, of St. Augustine, Fla., is now vice-president of Day and Zimmermann, Inc., of Philadelphia, Pa.

NOBLE W. HERZBERG, who is with the U. S. Geological Survey, has been transferred from Albany, N.Y., to Binghamton, N.Y., where he is in charge of the newly established suboffice of the Survey.

GEORGE H. SAGER, JR., state director for the Public Works Administration in Kentucky, was recently elected president of the Kentucky Society of Professional Engineers.

VINCENT J. DOBROCHOWSKI, formerly with the General Railway Signal Company at Rochester, N.Y., is now an engineering apprentice in the maintenance of way department of the Pennsylvania Railroad Company at Fort Wayne, Ind.

I. W. PUGH, previously designing engineer in the office of the bridge engineer of the Lehigh Valley Railroad at Bethlehem, Pa., has taken a position with the Aluminum Company of Canada, Ltd. His headquarters are at Arvida, Quebec.

CHARLES S. WHITNEY, consulting engineer of Milwaukee, Wis., has been awarded the Fuertes gold medal by Cornell University for his research in the design of concrete structures. The award was based on a paper published in the *Journal of the American Concrete Institute*, describing new methods of designing reinforced concrete structures.

CRAIG P. HAZELET, with Ingolf Erdal, has formed a partnership for the practice of consulting engineering under the firm name of Hazelet and Erdal, with headquarters in the Monadnock Block, Chicago, Ill. Mr. Hazelet was formerly president and chief engineer of the Scherzer Rolling Lift Bridge Company, of the same city.

E. M. RETIEF is now assistant engineer for the Glencoe-Volksrust Improvements at Glencoe, Union of South Africa. He formerly held a similar position with the South African Railways at East London, Union of South Africa.

INGE LYSE, professor of engineering materials at Lehigh University, has been awarded one of the 1937 medals of the Franklin Institute. The award goes to Professor Lyse for his series of papers on "A Study of the Quality, the Design and the Economy of Concrete," published in the April, May, June, and July 1936 issues of the journal of the Institute.

EDWIN H. MARKS, lieutenant colonel, Corps of Engineers, U. S. Army, has been transferred from Galveston, Tex., where he was district engineer, to Buffalo, N.Y. Colonel Marks will serve in the same capacity at Buffalo.

LEE M. BUSH is now construction engineer for Sivalls and Bryson, manufacturers of oil refinery equipment. He will supervise enlargement of the company's plant in Oklahoma City, Okla. Mr. Bush was formerly city engineer of Oklahoma City.

R. L. MCCORMICK is retiring as head of the civil engineering school at Rose Polytechnic Institute, after forty-five years at the Institute.

EDWARD E. REEDY, formerly assistant material and specification engineer for the WPA in Ohio, is now employed as an engineer by the Pollak Steel Company in Cincinnati, Ohio.

GEORGE B. DUBOIS is now field representative for the Government's Social Security Board at Duluth, Minn.

WILLIAM T. DORRANCE, JR., has taken a position with the Arundel Corporation on the electrification of the Pennsylvania Railroad. His headquarters are at Columbia, Pa.

C. W. MCCLAIN, until recently engineer of maintenance for the Indiana State Highway Commission, is now Indiana representative for the Bitucote Products Company, of St. Louis, Mo.

M. R. KEEFE was recently elected president of the Indiana Engineering Council.

W. W. HORNER, consulting engineer of St. Louis, Mo., has been appointed professor of municipal and sanitary engineering at Washington University in St. Louis, the appointment to be effective in the fall. Mr. Horner will continue to maintain his consulting practice.

HARRY E. BOVAY, JR., has resigned his position in the U. S. Engineer Office at Vicksburg, Miss., to become connected with the Humble Oil and Refining Company, with headquarters at Baytown, Tex.

G. GALE DIXON, consulting engineer of Youngstown, Ohio, has accepted a position as chief flood control engineer for the Water and Power Resources Board of the Pennsylvania Department of Forests and Waters, at Harrisburg, Pa.

WOODLAND G. SHOCKLEY has left the employ of the Buckeye Incubator Company at Springfield, Ohio, to become a draftsman for the Skinner Irrigation Company, of Troy, Ohio.

ERNEST B. HUSSEY, consulting civil engineer of Seattle, Wash., has been elected president and chief engineer of the Seattle Terminal Board, with offices in the same city.

ALEXANDER BONNYMAN was recently elected president of the Blue Diamond Coal Company, Inc., at Knoxville, Tenn. He was previously chairman of the board of directors of this company.

COMPERE LOVELESS, formerly project engineer for the Indiana State Highway Commission, is now in the Ambridge (Pa.) plant of the American Bridge Company.

E. FORBES LAFLIN has resigned from the U. S. Bureau of Reclamation to accept employment as a senior engineering aid in the California Division of Highways. He is now located at Berkeley, Calif.

RUSSELL C. BRINKER has accepted an appointment to teach in the college of applied science of the University of Hawaii, Honolulu, T. H. He was formerly in the civil engineering department at Worcester Polytechnic Institute, Worcester, Mass.

EDWIN A. INGHAM, for the past eleven years city manager of Coronado, Calif., has been appointed city manager of Glendale, Calif.

C. R. MERRIMAN has left the State Highway Commission of Indiana to accept a position in the Logansport division office of the Pennsylvania Railroad.

KENNETH T. ATWELL is now employed as an engineer for the Austin Company at Oakland, Calif. He was previously an estimator for the Soulé Steel Company in San Francisco, Calif.

ANTHONY DE BIASE has resigned from the New York City Department of Parks to become a junior engineer with the Port of New York Authority, New York City. His work is in connection with the Lincoln Tunnel Project.

DECEASED

CHRISTIAN PETER JENSEN (M. '19) county engineer and surveyor of Fresno County, California, died at his home in Fresno on May 5, 1937. Mr. Jensen, who was 63, was born in Contra Costa County and educated at the Naillens School of Engineering in San Francisco. From 1901 to 1904 he was chief engineer for the Madera Sugar Pine Company; from 1909 to 1913, city engineer of Fresno; and from 1910 to 1919, city engineer of Reedley, Sanger, Clovis, and Fowler. In the latter year he became county engineer and surveyor. Mr. Jensen developed the Jensenite paving process, which was widely used and eliminated the payment of royalties to private paving concerns.

FRANKLIN CALHOUN PILLSBURY (M. '09) project engineer for the Massachusetts State Department of Public Works, died at his home in Brookline, Mass., on May 15, 1937. Mr. Pillsbury, who was 67, was born in Chicago, Ill. From 1886 to 1895 he was in the engineering office of Ernest W. Bowditch, of Boston, and from 1896 to 1920 he was with the Massachusetts Highway Commission—first as resident engineer on highway construction and later as division engineer. In 1920 Mr. Pillsbury became construction engineer for the Massachusetts State Department of Public Works, and from 1923 on he was project engineer in charge of surveying, designing, location and layout, and preparation of contracts and specifications.

The Society welcomes additional biographical material to supplement these brief notes and to be available for use in the official memoirs for "Transactions."

CLARENCE DU BOIS POLLOCK (M. '05) consulting engineer and chief resident engineer inspector of the PWA of New York City, died on April 30, 1937, at the age of 65. Mr. Pollock was born in Washington, D.C., and graduated from the Massachusetts Institute of Technology in 1894. From 1895 to 1900 he was assistant engineer in the Brooklyn (N.Y.) Department of Highways. After two years as chief assistant engineer to Calvin Hendricks in rerouting the new sewer lines, he became assistant engineer of highways in the Brooklyn Department of Public Works. From 1911 to 1913 he was chief engineer of the Department of Paving of Havana, Cuba, and in 1914 he established his consulting practice in New York City. Mr. Pollock also served as consulting engineer for the Granite Paving Association from 1915 to 1930, and he was special lecturer on highway construction at various universities.

HENRY RADCLYFFE ST. ARVANS WALTERS (Assoc. M. '05) who was in the sales department of the Bethlehem Steel Company, Bethlehem, Pa., died on February 23, 1937. Mr. Walters was born in Ashby, England, in 1876, and graduated from Lehigh University in 1903. He was with the Guerber Engineering Company from the latter year until 1908, when he began his long connection with the Bethlehem Steel Company. He was employed, successively, as superintendent of the fabricating shop, engineer of fabrication, and manager of the fabrication and erection department. From 1931 to 1935 he was assistant to the president of the McClintic-Marshall Corporation, a subsidiary of the Bethlehem Steel Company.

WILLARD OLNEY WHITE (M. '11) died at his home in Uniontown, Pa., on May 19, 1937, at the age of 60. Mr. White was born in Delta, N.Y., and graduated from Cornell University in 1900. From 1901 to 1902 he was assistant division engineer for the H. C. Frick Company; from 1904 to 1907, assistant engineer on the New York State Barge Canal; from 1907 to 1910, chief engineer for the Tower Hill Company; from 1911 to 1916, in private practice at Uniontown; and from 1916 to 1918, engineer on development for the Youngstown Sheet and Tube Company at Nemacolin, Pa. In the latter year Mr. White became resident engineer for W. J. Rainey, Inc., at Uniontown, where he remained until April 1936, when he retired on account of illness.

WALTER MCILHANEY WOLFE (Assoc. M. '19) resident vice-president of the North-Eastern Construction Company, Baltimore, Md., died suddenly on May 11, 1937, at the age of 49. Colonel Wolfe was born in Chatham, N.J., and graduated from the Virginia Military Institute in 1908. His early career included a variety of engineering experience, and in 1912 he became principal assistant engineer with Frederick L. Cranford, Inc., on construction of part of the New York City subway system. He resigned in 1917 to serve overseas as captain in the Sixth Engineers, and later he had the rank of colonel in the 375th Reserve Regiment of Engineers. Upon his return from France, Colonel Wolfe became resident vice-president of the North-Eastern Construction Company.

Changes in Membership Grades

Additions, Transfers, Reinstatements, and Resignations

From May 10 to June 9, 1937, Inclusive

ADDITIONS TO MEMBERSHIP

ALLARDICE, WILLIAM DUNCAN (Assoc. M. '37), Supt. of Constr., M. H. McCloskey Co. (Res., 735 East Haines St.), Philadelphia, Pa.

ATLAS, WILLIAM (Jun. '37), 1701 Eastburn Ave., New York, N.Y.

BENNETT, HARRY JACKSON (M. '37), Chf. Civ. Engr., Bethlehem Steel Co., Cambria Plant (Res., 304 Orchard St.), Johnstown, Pa.

BONE, ALEXANDER JAMIESON (Assoc. M. '37), Asst. Prof., Highway Eng., Mass. Inst. Tech., Room 1-339, Mass. Inst. Tech., Cambridge (Res., 228 Manthorne Rd., West Roxbury), Mass.

BROCKMAN, FREDERICK HENRY (Jun. '37), Junior Engr., U. S. Engr. Office, Pittsburgh, Pa.

CALLINAN, BERNARD JAMES (Jun. '37), Asst. Engr., A. Gordon Gutteridge, 440 Little Collins St. (Res., 23 Carlyle St., Moonee Ponds, W. 4), Melbourne, Victoria, Australia.

COTTER, RALPH EVANS, JR. (Jun. '37), Draftsman, Eng. Dept., City of Oakland (Res., 100 Hermosa Ave.), Oakland, Calif.

CUNNINGHAM, THOMAS PATRICK (M. '37), Asst. Engr., New York City, for Pres., Borough of Queens, Topographical Bureau, Long Island City (Res., 85-22 One Hundred and Twenty-Fourth St., Richmond Hill), N.Y.

DE BIASE, ANTHONY (Jun. '37), Junior Engr., Port of New York Authority, 483 Eleventh Ave. (Res., 613 East 6th St.), New York, N.Y.

DOWLING, WALLACE EUGENE (Jun. '37), Bridge Designer, State Dept. of Roads and Irrig. (Res., 2641 Sewell St.), Lincoln, Nebr.

DUNLOP, HUGH B. GIBSON (Jun. '37), Chainman, U. S. Bureau of Reclamation, Box 77, Coulee Dam, Wash.

DUNLOP, JOHN ARLINGTON (Jun. '37), Instr., Civ. Eng., Rensselaer Polytechnic Inst. (Res., 2216 Sixteenth St.), Troy, N.Y.

ESTRADA, ALFRED ALBERT (Jun. '37), Asst. Engr., Albright & Friel, Inc. (Res., 2323 North Carlisle St.), Philadelphia, Pa.

FLINSCH, HAROLD VON NEUFVILLE (Jun. '37), Research Asst., Hydraulics Div., Univ. of Minnesota (Res., 630 South East 7th St.), Minneapolis, Minn.

FOLEY, JOSEPH (Jun. '37), Draftsman, P.R.R., 15 North 32d St., Philadelphia, Pa. (Res., 441 Haddon Ave., Camden, N.J.).

GROSHONG, WALTER C. (Assoc. M. '37), Res. Engr. and Asst. to Supt., United Constr. Co. (Res., 1900 Ford St.), Golden, Colo.

HAGEDORN, HECTOR EDMUND (Jun. '37), Asst. Project Engr., Parks, WPA, New York (Res., Hotel St. George, Brooklyn), N.Y.

HEARN, CHAUNCEY MARTIN (Assoc. M. '37), Junior Engr., U. S. Engr. Dept., U. S. Engr. Office, Providence, R.I.

HENDRICKSEN, PAUL JOHN (Jun. '36), 1835 East William St., Decatur, Ill.

HOUGHTALING, BYRON (M. '37), Div. Engr., Board of Transportation, 250 Hudson St., New York, N.Y.

HRENNIKOFF, ALEXANDER (Assoc. M. '37), Instr., Dept. of Civ. Eng., Univ. of British Columbia, Vancouver, B.C., Canada.

IRWIN, WILLIAM BENTLEY (M. '37), Asst. to Vice-Pres., Operation, G.N.Ry. (Res., 202 South Baldwin St.), St. Paul, Minn.

JENNINGS, HAL JUDSON (Assoc. M. '37), Asst. Engr., U. S. Bureau of Reclamation, Denver, Colo.

JOHNSON, LOYS ALMON (Jun. '37), Asst. Structural Engr., TVA, Knoxville, Tenn.

JOST, LESLIE GORDON (M. '37), Chf. Engr., Consolidated Steel Corporation, Ltd. (Res., 8342 Kirkwood Drive), Los Angeles, Calif.

KARRICK, SAMUEL NAIRN (M. '37), Capt., Corps of Engrs., U.S.A., Acting Dist. Engr., Chicago Dist., U. S. Engr. Office, Room 932, U. S. Post Office Bldg., Chicago, Ill.

KREIPKE, MERRILL VINCENT (Jun. '37), 1100 North Baker Ave., Evansville, Ind.

KRUEGER, WALTER, JR. (Jun. '37), Lieut., Corps of Engrs., U.S.A., Asst. Prof., Military Science and Tactics, Clarkson Coll. of Technology, Box 424, Potsdam, N.Y.

LARSON, HOWARD DREW (Jun. '37), Junior Engr., U. S. Bureau of Reclamation, Room 467, Custom House, Denver, Colo.

LAUCOMER, GEORGE FRANKLIN (Jun. '36), Draftsman, Giffels & Vallet, Inc., Box 223, Detroit, Mich.

MAXWELL, CLYDE VERNON, JR. (Jun. '37), care, Gardner and Howe, Porter Bldg., Memphis, Tenn.

MURPHY, THORIST FILMORE (Assoc. M. '37), Associate Engr., U. S. Geological Survey, Box 346, Sacramento, Calif.

NEIMAN, ABRAHAM SAMUEL (Assoc. M. '37), Asst. Highway Engr., State Bureau of Bridges (Res., 213 South English Ave.), Springfield, Ill.

NELSON, EDWARD SEVERY (M. '37), Archt.-Engr. (C. H. Johnston), 715 Empire Bank Bldg., St. Paul, Minn.

O'FARRELL, HARRY OLIVER (Assoc. M. '37), Constr. Engr. and Mgr., Contr. Div., Brownsville Constr. Co., Inc. (Res., 9 Playford Ave.), Brownsville, Pa.

OLSON, EMERY DONALD (Jun. '37), Asst., Univ. of Illinois (Res., 807 West Nevada St.), Urbana, Ill.

OTTO, ARTHUR LOUIS (Jun. '37), Draftsman, The Port of New York Authority, 111 Eighth Ave., New York, N.Y. (Res., 14 North Walnut St., East Orange, N.J.).

TOTAL MEMBERSHIP AS OF JUNE 9, 1937	
Members	5,668
Associate Members	6,123
Corporate Members	11,791
Honorary Members	24
Juniors	3,507
Affiliates	87
Fellows	1
Total	15,410

PAINTER, WILFRED LEWIS (Assoc. M. '37), Archt. and Engr. (Graham & Painter, Ltd.), 1501 Dexter Horton Bldg., Seattle, Wash.

PETERSON, CARLTON JAMES (Jun. '36), With Dept. of Power and Light, City of Los Angeles, Independence (Res., 314 South Helena St., Anaheim), Calif.

PITT, JOHN FLOYD (Assoc. M. '37), Structural Designer, Phoenix Eng. Corporation, 2 Rector St., New York, N.Y. (Res., 9 Grove St., North Plainfield, N.J.).

PORTER, WARREN LESLIE (M. '37), Rate and Appraisal Engr., The United Light and Power Eng. & Constr. Co. (Res., 257 Fernwood Ave.), Davenport, Iowa.

QUILTY, PATRICK (M. '37), Deputy Chf. Engr., Supervision of Operation, Water Supply System, City of New York (Res., 601 West 163d St.), New York, N.Y.

RANDALL, GIFFORD MYRON (Jun. '37), 1443 Josephine St., Berkeley, Calif.

REEDY, EDWARD EGAN (Jun. '37), Engr., Pollak Steel Co. (Res., 3810 Kenker Pl.), Cincinnati, Ohio.

REICH, STANLEY SCHWARTZ (Assoc. M. '37), Engr., New York Office, The Arundel Corporation, Pier 3, Fulton St. (Res., 9747 Shore Rd.), Brooklyn, N.Y.

RICCIO, JOSEPH GEORGE ANTHONY (Jun. '37), Surveyman, U. S. Engr. Office, Providence (Res., 24 De Wolf Ave., Bristol), R.I.

ROBERTSON, GORDON WALTER (Jun. '36), Surveyman, Sacramento Air Depot; General Delivery, Rio Linda, Calif.

ROCKETT, LOUIS NEWBERN (Jun. '36), With State Highway Dept. (Res., 1120 Main St.), Hattiesburg, Miss.

SAVAGE, LUKE FRANCIS (M. '37), City Engr., 617 Peoples Bank Bldg., McKeesport, Pa.

SCHMECKPEPER, HENRY LUDOLF (Assoc. M. '37), Asst. Engr., Arthur A. Johnson Corporation, 29-28 Hunter Ave., Long Island City, N.Y.

SCOTT, RODNEY JEROME (Jun. '37), Detailer, Betnlehem Steel Co. (Res., 743 Grande Ave.), San Francisco, Calif.

SMITH, FREDERIK EGID (Assoc. M. '37), Cons. Engr., 210 Foreman Bldg., Houston, Tex.

SMITH, WARREN AUSTIN (M. '37), Cons. Engr., Box 1048, Jacksonville, Fla.

SOUTHERLAND, HENRY DELEON, JR. (Jun. '37), Asst. Eng. Aide, TVA (Res., 1525 West Laurel Ave.), Knoxville, Tenn.

STANLEY, RANDOLPH LEE (Jun. '37), Transitman, U. S. Bureau of Reclamation, 414 H St., Antioch, Calif.

STARKE, DICK DRYDEN (Assoc. M. '37), Asst. Highway Engr., Grade Separations, State Div. of Highways (Res., 1819 South 6th St.), Springfield, Ill.

STARR, MARK ELWOOD (Jun. '37), South Market St., Selinsgrove, Pa.

STULL, JOSEPH SMITH (M. '37), Senior Designing Engr., Board of Water Supply, New York (Res., 37 Sand Gap St., Eltingville), N.Y.

TARAGIN, ASRIEL (Jun. '36), 1119 East Baltimore St., Baltimore, Md.

THOMPSON, ARTHUR ROY (Assoc. M. '36), Engr. Examiner, PWA for Nevada, Box 1045, Reno, Nev.

THRAPP, HARRISON FRANCIS (Jun. '37), 6812 Dorchester Ave., Apartment 3-16, Chicago, Ill.

TRIGGS, JAMES FREDERICK (Jun. '37), Asst. Dist. Engr., Highway Dist. 11, State Dept. of Highways (Res., 6643 Ridgeville St.), Pittsburgh, Pa.

WALBRIDGE, SMITH STARR (Jun. '37), Junior Asst. Engr., State Dept. of Public Works, Div. of Highways, Babylon (Res., 333 East 53d St., New York), N.Y.

WAX, LESLIE (Jun. '37), Estimator and Supervisor, T. Fred Jackson, Inc., New York (Res., 2662 Ocean Ave., Brooklyn), N.Y.

WEIR, PAUL (Jun. '37), Supt. of Water Purification and Chf. Chemist, in Chg., Water Purification Plants (Res., 1194 Hemphill Ave., N.W.), Atlanta Ga.

WELLS, WILLIAM LEONIDAS (Jun. '37), Junior Engr., U. S. Waterways Experiment Station (Res., 1415 Baum St.), Vicksburg, Miss.

ZALA, GEORGE THOMAS (Assoc. M. '37), Structural Engr., George B. Gascoigne and Associates, Cleveland (Res., 22 East 254th St., Euclid), Ohio.

MEMBERSHIP TRANSFERS

BLASCHKE, THEODORE OSCAR (Jun. '35; Assoc. M. '37), Structural Designer, New York Worlds Fair, 1939, 32-16 Two Hundred and Thirteenth St., Bayside, N.Y.

BLASER, ARTHUR FREDERICK (Assoc. M. '16; M. '37), Chf. Engr., Street Railroad Commr's. Office, City of Cleveland, 624 Republic Bldg., Cleveland, Ohio.

BLOXTON, CONWAY RUSSELL (Assoc. M. '24; M. '37), Dist. Engr., Am. Inst. of Steel Constr., Room 405, Bona-Allen Bldg., Atlanta, Ga.

CONNELL, GILBERT FETTERMAN (Jun. '30; Assoc. M. '37), Asst. Engr., U. S. Engr. Office (Res., 1508 Euclid Ave.), Zanesville, Ohio.

CROSETT, ALEXANDER DAVIS (Assoc. M. '22; M. '37), Cons. Engr., 512 Fifth Ave., New York, N.Y.

CUNNINGHAM, HUGH TANQUARY (Jun. '27; Assoc. M. '37), Longview, Tex.

DIEHL, PAUL ADAM (Assoc. M. '26; M. '37), Chemist and Engr., Black & Veatch, 4706 Broadway, Kansas City, Mo.

EASON, RALPH LEE (Jun. '30; Assoc. M. '36), Civ. Engr., Board of Public Service, City of St. Louis (Res., 2840 Watson Rd.), St. Louis, Mo.

EHLERS, RALPH BURLIN (Jun. '27; Assoc. M. '37), Designing Engr., The Dow Chemical Co. (Res., 216 West Ellsworth St.), Midland, Mich.

GOMEZ-PEREZ, FRANCISCO (Jun. '29; Assoc. M. '37), Engr. of Specifications, Eng. Dept., Mexican National Comm. of Irrig. (Res., 4 A Durango 74-C), Mexico, D.F., Mexico.

GRATHWOL, HENRY JACOB (Assoc. M. '19; M. '37), Associate Highway Engr., U. S. Dept. of Agriculture, Bureau of Public Roads, Dist. 10 (Res., 3511 Davenport St., N.W., Apartment 108), Washington, D.C.

HALB, HAL HENDERSON (Jun. '25; Assoc. M. '30; M. '37), City Engr., Box 1243 Knoxville, Tenn.

HOLLEY, HARRY HALL (Assoc. M. '09; M. '37), Hydr. and Irrig. Engr., Larkins Bldg., Visalia, Calif.

JOHNSON, ROBERT COLTON (Assoc. M. '26; M. '37), Asst. to State Director, NEC, 1809 Mariner Tower, Milwaukee, Wis.

KINGSCOTT, LOUIS CLIFTON (Jun. '23; Assoc. M. '26; M. '36), Archt. and Engr. (Stewart-Kingscott Co.), 208 Elm St. (Res., 2007 Winchell Ave.), Kalamazoo, Mich.

LATHAM, GEORGE ROBERT (Jun. '26; Assoc. M. '37), Squad Leader, Phoenix Eng. Corporation, New York, N.Y. (Res., 154 Midland Ave., East Orange, N.J.)

MACK, GEORGE JOHN (Jun. '25; Assoc. M. '37), Vice-Pres., Laur & Mack Contr. Co., Inc. (Res., 1317 Thorndale Ave.), Niagara Falls, N.Y.

MEANS, BOYD IRWIN (Assoc. M. '25; M. '37), Cons. Structural Engr., 5905 Pacific Boulevard, Huntington Park (Res., 156 West 76th St., Los Angeles), Calif.

MONROE, CLARENCE ALBERT (Jun. '30; Assoc. M. '37), Chf. Engr., Levitt & Sons, Northern Boulevard, Manhasset, N.Y.

MOORE, MORRISON BERT, JR. (Jun. '27; Assoc. M. '37), Asst. Engr., U. S. Engrs., Pittsburgh (Res., 709 Laughlin Ave., Aliquippa), Pa.

MOORE, WILLIAM BION (Jun. '28; Assoc. M. '37), Asst. Engr., Federal Power Comm. (Res., 1420 Vine St.), Denver, Colo.

PECKWORTH, HOWARD FARON (Jun. '27; Assoc. M. '31; M. '37), Res. Engr., Birmingham Industrial Water Supply Comm., Birmingham, Ala.

PREBLES, ARCHIBALD (Jun. '35; Assoc. M. '37), Instr., Univ. of British Columbia (Res., 2911 West 15th Ave.), Vancouver, B.C., Canada.

PITNEY, HARVEY MARSHALL (Jun. '30; Assoc. M. '37), Estimator and Designer, Bridge Dept., Bethlehem Steel Co., Fabricated Steel Constr. (Res., 728 High St.), Bethlehem, Pa.

PORZELIUS, ALBERT FREDRICK (Jun. '13; Assoc. M. '15; M. '37), Supt., City Water Co., Chattanooga, Tenn.

RETZKE, PAUL OTTO (Jun. '28; Assoc. M. '37), Asst. Civ. Engr., Q.M.C., U.S.A., Office of Quartermaster, Federal Office Bldg., Omaha, Nebr.

ROSENBERGER, RAYMOND JOYCE (Jun. '25; Assoc. M. '29; M. '37), Engr.-Examiner, Chf. of Planning Section, Projects Div., PWA, Interior Bldg., Washington, D.C.

SANDERSON, THEODORE HAROLD (Jun. '27; Assoc. M. '37), Asst. Engr. and Representative, Metallurgical Dept., Carnegie-Illinois Steel Corporation, 208 South La Salle St., Room 1366, Chicago, Ill.

SYLVESTER, HAROLD MACTAVISH (Jun. '29; Assoc. M. '36), Lieut., C.E.C., U.S.N. Asst. Officer-in-Chg., Public Works Constr. (Navy), Dist. of Columbia and Vicinity; Asst. Public Works Officer, Naval Air Station, Anacostia, D.C.

SYMNS, SAMUEL YOUNG (Jun. '31; Assoc. M. '37), Peterstown, W.Va.

THAXTON, RUFUS CARROLL (Assoc. M. '26; M. '37), Engr., U. S. Bureau of Reclamation, 200 Old Federal Bldg., Sacramento, Calif.

THEUER, ARTHUR ULRICH (Jun. '28; Assoc. M. '37), Asst. Materials Engr., U. S. Bureau of Standards (Res., 3409 Newark St.), Washington, D.C.

THOMAS, THEODOR WILLIAM (Jun. '28; Assoc. M. '37), Senior Engr., State Highway Dept. (Res., 2075 Juno St.), St. Paul, Minn.

VON BERGEN, HAROLD EMIL (Jun. '30; Assoc. M. '36), Water Master, Div. of Water Resources, State Dept. of Water Rights (Res., 3101 Montgomery Way), Sacramento, Calif.

WATTS, JOSEPH CLYDE (Jun. '27; Assoc. M. '37), Asst. Engr., U. S. Engr. Office, 605 Federal Bldg., Detroit, Mich.

REINSTATEMENTS

COLLIER, THEODORE FRANKLIN, Assoc. M., reinstated Apr. 14, 1937.

HANSON, ROBERT ANDREW, Assoc. M., reinstated May 24, 1937.

SCHMITT, WALTER FREDERICK, Jun., reinstated May 13, 1937.

WILLS, BENJAMIN HAROLD, Assoc. M., reinstated Apr. 13, 1937.

RESIGNATIONS

HARVEY, MARVIN SPEARS, Assoc. M., resigned May 20, 1937.

LOPEZ DE ROMAÑA, EDUARDO CARLOS, Jun., resigned May 18, 1937.

VEECH, JOHN ALEXANDER, Jun., resigned May 14, 1937.

Applications for Admission or Transfer

Condensed Records to Facilitate Comment of Members to Board of Direction

July 1, 1937 — NUMBER 7

The Constitution provides that the Board of Direction shall elect or reject all applicants for admission or for transfer. In order to determine justly the eligibility of each candidate, the Board must depend largely upon the membership for information.

Every member is urged, therefore, to scan carefully the list of candidates published each month in CIVIL ENGINEERING *and to furnish the Board with data which may aid in determining the eligibility of any applicant.*

It is especially urged that a definite recommendation as to the proper grading be given in each case, inasmuch as the grading must be based upon the opinions of those who know the applicant personally as well as upon the nature and extent of his professional experience. Any facts derogatory to the personal character or professional reputation of an applicant should be promptly communicated to the Board.

Communications relating to applicants are considered strictly confidential.

The Board of Direction will not consider the applications herein contained from residents of North America until the expiration of 30 days, and from non-residents of North America until the expiration of 90 days from the date of this list.

MINIMUM REQUIREMENTS FOR ADMISSION

GRADE	GENERAL REQUIREMENT	AGE	LENGTH OF ACTIVE PRACTICE	RESPONSIBLE CHARGE OF WORK
Member	Qualified to design as well as to direct important work	35 years	12 years*	5 years of important work
Associate Member	Qualified to direct work	27 years	8 years*	1 year
Junior	Qualified for sub-professional work	20 years†	4 years*	
Affiliate	Qualified by scientific acquirements or practical experience to cooperate with engineers	35 years	12 years*	5 years of important work
Fellow	Contributor to the permanent funds of the Society			

* Graduation from an engineering school of recognized reputation is equivalent to 4 years of active practice.

† Membership ceases at age of 33 unless transferred to higher grade.

The fact that applicants refer to certain members does not necessarily mean that such members endorse.

ADMISSIONS

ABELL, JULIAN DAVID, Ft. Belvoir, Va. (Age 30.) Refers to E. N. Burrows, S. C. Hollister, E. W. Schoder, P. J. Seery, L. C. Urquhart.

ADAMS, JAMES EDWIN, Harrodsburg, Ky. (Age 24.) Refers to R. E. Shaver, D. V. Terrell.

ADAMS, MILTON PRAY, East Lansing, Mich. (Age 43.) Executive Secy. and Engr., Michigan Stream-Control Comm. Refers to L. M. Gram, S. A. Greeley, W. C. Hoad, E. D. Rich, H. E. Riggs, J. R. Rumsey, C. O. Wisler.

ALLEN, WILLIAM B, Knoxville, Tenn. (Age 58.) Project Design Engr., TVA. Refers to W. G. Fargo, C. B. Hawley, H. S. Hunt, E. Maerker, R. M. Riegel, A. Streiff.

AMNEUS, THOMAS AXEL, Oakland, Calif. (Age 30.) Refers to R. E. Davis, C. Derleth, Jr., B. A. Etcheverry, C. G. Hyde, B. Jameyson, G. E. Troxell, C. T. Wiskocil.

ANDERSON, IVAR, Brooklyn, N.Y. (Age 38.) With Damon G. Douglas Co., Newark, N.J. Refers to E. K. Abberley, H. W. Ferris, L. C. Kuhl, Jr., F. X. Scanlan, W. C. Voss.

ANDRUS, JOSEPH WESLEY, Marion, Utah. (Age 27.) Refers to H. S. Carter, G. D. Clyde, F. W. Cottrell, O. W. Israelsen, H. R. Kepner.

BACH, WILLIAM KENNETH, Nyssa, Ore. (Age 26.) Refers to H. S. Carter, G. D. Clyde, O. W. Israelsen, H. R. Kepner.

BARFOOT, LEVERETTE HALE, Stephenville, Tex. (Age 22.) Refers to L. E. Grinter, J. T. L. McNew, T. A. Munson, J. A. Orr, J. J. Richey, C. E. Sandstedt.

BARNES, WILLIAM WRIGHT, JR., Fort Worth, Tex. (Age 21.) Refers to L. E. Grinter, J. T. L. McNew, T. A. Munson, J. A. Orr, J. J. Richey, C. E. Sandstedt.

BAUNACH, ROBERT WILLIAM, South Orange, N.J. (Age 22.) Refers to F. A. Barnes, C. Derleth, Jr., C. G. Hyde, B. Jameyson, H. N. Ogden, C. L. Walker, C. T. Wiskocil.

BLACK, ROBERT SIGMAN, JR., Clifton, Ariz. (Age 23.) Refers to L. E. Grinter, J. T. L. McNew, J. A. Orr, J. J. Richey, C. E. Sandstedt.

BOLES, CHALMERS MORTON, Turon, Kans. (Age 22.) Refers to L. E. Conrad, F. F. Frazier, M. W. Furr, L. V. White.

BORG, GRANT KENNETH, Salt Lake City, Utah. (Age 24.) Refers to T. C. Adams, R. K. Ketchum.

BOSWELL, LEO DELBERT, Tulsa, Okla. (Age 31.) Draftsman, American Steel Derrick Co. Refers to J. E. Kirkham, E. R. Stapley.

BOYER, FRANK WOODRUFF, JR., Greensboro, N.C. (Age 31.) Pres., Boyer Constr. Co., Inc. Refers to G. G. Blackmore, F. S. Crowell, H. J. Deutschbein, H. Englander, A. Fischer, Jr., G. L. Freeman, N. A. Melick, W. H. Muesser, W. M. Paddock, G. V. Salle.

BRANT, ROGER WILLIAM, Santa Barbara, Calif. (Age 25.) Refers to B. A. Etcheverry, C. T. Wiskocil.

BREUER, WALTER FRANKLIN, Rolla, Mo. (Age 21.) Refers to C. E. S. Bardsley, J. B. Butler, E. W. Carlton, C. V. Mann.

BROWNE, HOWARD CARL, Brooklyn, N.Y. (Age 22.) Refers to G. J. Davis, Jr., J. S. Leister.

BYINGTON, ROBERT RICHARD, Chicago, Ill. (Age 22.) Refers to C. A. Ellis, R. B. Wiley.

CASTELAN, JOE TERRAZAS, Nogales, Ariz. (Age 26.) Refers to E. S. Borgquist, F. C. Kelton, J. C. Park.

CAVIN, HAROLD DANIEL, Tacoma, Wash. (Age 39.) Res. Engr. on construction, with St. Regis Kraft Co. (Pulp Mill), Tacoma, Wash. Refers to W. R. Engstrom, H. S. Ferguson, O. H. Hallberg, J. P. Hart, C. P. Ryan.

CHAO, CHARLES FANG, Palo Alto, Calif. (Age 24.) Refers to E. L. Grant, S. B. Morris, L. B. Reynolds.

CHARLTON, KENNETH JAMES, Berkeley, Calif. (Age 21.) Refers to C. Derleth, Jr., H. A. Schirmer.

COSTELLO, NICHOLAS MARTIN, Brooklyn, N.Y. (Age 32.) Engr. with C. Bakke, New York City. Refers to W. G. Bank, S. G. Hess, A. B. Kozma, J. L. Lenox, J. H. Philips, A. Potter.

COTTER, AUGUSTINE JOSEPH, Lawrence, Mass. (Age 34.) Res. Engr. Inspector, FEA of PW. Refers to N. Epstein, M. E. Gilmore, S. G. Hess, J. D. Moore, A. N. Mulholland, W. W. Peabody.

CREW, ALFRED, III, Bluefield, W.Va. (Age 23.) With Morris Knowles, Inc., as Asst. to Res. Engr. Refers to F. A. Barnes, W. Jupenlaz.

DAIL, LAWRENCE RUFUS, Yuma, Ariz. (Age 32.) Engr., Pleasant-Halser Constr. Co., Phoenix, Ariz. Refers to J. A. Fraps, R. A. Hoffman, F. C. Kelton, W. W. Lane, R. V. Leeson, F. S. Merrill, G. F. Sparhawk, J. A. Vrydagh.

DAMON, HENRY GILROY, Sharon Hill, Pa. (Age 35.) Asst. Engr., Damon & Foster. Refers to W. H. Connell, A. F. Damon, Jr., C. E. Davis, C. A. Emerson, Jr., N. Foster, H. M. Freeburn, C. E. Parry, E. B. Temple.

DAVIDSON, JOHN KING, Eagle Lake, Tex. (Age 25.) Refers to F. E. Giesecke, L. E. Grinter, J. T. L. McNew, T. A. Munson, J. A. Norris, C. E. Sandstedt.

DAVIS, BERTON EMERSON, Scranton, Pa. (Age 24.) Clerk, Pennsylvania Liquor Control Board. Refers to L. Perry, E. H. Rockwell, G. F. Roehrig.

DAVIS, JACOB FREDRICK, Rapid City, S.Dak. (Age 26.) Refers to A. A. Chenoweth, E. D. Dake.

DEWEY, JOHN MARION, Kansas City, Mo. (Age 21.) Refers to C. E. S. Bardsley, J. B. Butler, E. W. Carlton.

DILLON, GLEN EARL, San Rafael, Calif. (Age 21.) Refers to C. Derleth, Jr., C. T. Wiskocil.

DILLON, WILLIAM SHERIDEN, JR., Longview, Tex. (Age 22.) Refers to L. E. Grinter, J. T. L. McNew, T. A. Munson, J. A. Orr, J. J. Richey, C. E. Sandstedt.

DOOLITTLE, ALBERT WHITING, JR., East Derry, N.H. (Age 22.) Refers to F. W. Garran, W. P. Kimball.

FAY, ALFRED LESTER, Denver, Colo. (Age 40.) Associate Engr., U. S. Bureau of Reclamation, Denver, Colo. Refers to R. W. Burpee, F. B. Cook, Jr., E. A. Dow, R. A. Monroe, G. R. Rich, I. A. Winter.

FIMBEL, PAUL NIVER, Maplewood, N.J. (Age 23.) Instructor in Civ. Eng., Stevens Inst. of Technology. Refers to W. D. Ennis, D. L. Snader.

FINE, HYMAN JOSEPH, Norfolk, Va. (Age 30.) Asst. Engr., U. S. Engr. Office. Refers to

C. C. Babb, F. B. Harkness, W. T. Howe, F. M. Keller, G. H. Matthes, G. R. Young.

FINK, HOWARD LLEWELLYN, Tucson, Ariz. (Age 28.) Refers to E. S. Borgquist, F. C. Kelton, J. C. Park.

FOOS, MICHAEL EDWARD, Schenectady, N.Y. (Age 25.) Graduate student and Special Research Asst. in Civ. Eng., Univ. of Illinois, Champaign, Ill. Refers to R. W. Abbett, H. Cross, R. A. Hall, A. de H. Hoadley, W. C. Huntington, W. C. Taylor.

FISHER, CHARLES ROSWELL, Chattanooga, Tenn. (Age 51.) With U. S. Geological survey as Tech. Adviser and Trainer of TVA field parties. Refers to C. H. Birdseye, A. S. Fry, H. H. Hodgeson, T. P. Pendleton, C. L. Sadler, L. S. Smith, J. G. Staack, G. D. Whitmore, R. M. Wilson.

FORREST, CASWELL UNDERWOOD, Dallas, Tex. (Age 21.) Refers to L. E. Grinter, J. T. L. McNew, T. A. Munson, J. A. Orr, J. J. Richey, C. E. Sandstedt.

GEISSER, GEORGE JOHN, Providence, R.I. (Age 38.) Chf. Engr., Public Bldgs. Dept. Refers to H. W. Congdon, H. Ise, E. F. Kriegsman, C. A. Maguire, F. B. Marsh, G. H. Potter, W. C. Voss.

GILBERTH, JOE CLYDE, Sulphur Springs, Tex. (Age 20.) Refers to L. E. Grinter, J. T. L. McNew, T. A. Munson, J. J. Richey, C. E. Sandstedt.

GREY, ANDREW MELROSE, Victoria, Tex. (Age 23.) Refers to W. A. King, J. T. L. McNew, J. J. Richey.

HACKMANN, GLEN NICKOLAS, St. Louis, Mo. (Age 23.) Refers to C. E. S. Bardsley, J. B. Butler, E. W. Carlton.

HADDOCK, FREDERICK RAYMOND, Philadelphia, Pa. (Age 44.) Chf. Engr. with Roberts Filter Mfg. Co., Darby, Pa. Refers to N. Foster, F. deS. Friel, F. F. Longley, H. S. R. McCurdy, C. F. Mebus, W. C. Olsen, S. N. Van Trump, C. E. Waddell.

HAGER, MILTON BLANCHARD, Lowell, Mass. (Age 48.) Asst. Civ. Engr., War Dept., Engr. Dept.-at-Large. Refers to J. E. Allen, H. J. Casey, F. P. Fifer, A. T. Safford, R. M. Strohl, J. Sweeney, R. C. Vogt.

HALL, HAROLD MAULDING, Fort Peck, Mont. (Age 26.) Sub-Inspector of Dredging, U. S. Engr. Dept. Laboratory. Refers to C. E. S. Bardsley, J. B. Butler, E. W. Carlton, P. B. Heidema, H. W. Russell, H. L. Weil.

HASS, ARTHUR EDWARD, Mission, Tex. (Age 23.) Refers to L. E. Grinter, H. H. Kidder, J. T. L. McNew, T. A. Munson, J. A. Orr, J. J. Richey, C. E. Sandstedt.

HEALD, HOWARD LEWIS, Rapid City, S.Dak. (Age 21.) Refers to A. A. Chenoweth, E. D. Dake.

HERZIK, MELVIN CLYDE, Austin, Tex. (Age 20.) Refers to J. T. L. McNew, J. A. Orr.

HILL, GEORGE ARTHUR, Oakland, Calif. (Age 20.) Refers to R. E. Davis, C. T. Wiskocil.

HOMMON, JAMES BRITTON, Grand Canyon, Ariz. (Age 21.) Grand Canyon National Park. Refers to C. G. Hyde, B. Jameyson.

HORNSBY, GROVER JACKSON, Denver, Colo. (Age 44.) Engr., U. S. Bureau of Reclamation. Refers to C. M. Allen, F. E. Hale, S. O. Harper, J. L. Savage, R. F. Walter, I. A. Winter, S. H. Woodard.

HOROWITZ, FERMOND CECIL, Los Angeles, Calif. (Age 23.) Refers to B. A. Etcheverry, C. T. Wiskocil.

HUBBELL, GEORGE EDGAR, Detroit, Mich. (Age 30.) With Hubbell, Hartgering & Roth, Inc., Cons. Engrs.; also Instructor in Civ. Eng., Wayne University. Refers to C. O. Barton, G. H. Fenkell, E. A. Hardin, C. W. Hubbell, A. B. Morrill, D. Newton, A. Roth, M. F. Wagnitz.

IRWIN, JOHN PAULETTE, Topeka, Kans. (Age 23.) Refers to L. E. Conrad, F. F. Frazier, M. W. Furr, R. F. Morse, R. J. Paulette.

ITSCHNER, EMERSON CHARLES, Webster Groves, Mo. (Age 34.) Capt., Corps of Engrs., U. S. Army; Asst. to Div. Engr., Upper Mississippi River Valley. Refers to H. Austill, C. E. S. Bardsley, J. B. Butler, E. W. Carlton, M. Elliott, A. F. Griffin.

JORGENSEN, LEONARD NIELSEN, Hyrum, Utah. (Age 21.) Refers to H. S. Carter, G. D. Clyde, O. W. Israelsen, H. R. Kepner.

KAMMERER, RUDOLPH MITCHELL, Westhampton Beach, N.Y. (Age 25.) Refers to G. J. Davis, Jr., S. C. Houser, J. S. Leister.

KEENAN, WILLIAM HENRY, JR., West Lafayette, Ind. (Age 20.) Refers to C. A. Ellis, R. B. Wiley.

KEPENACH, JULIUS, Detroit, Mich. (Age 22.) Refers to G. C. Dillman, W. C. Polkinghorne.

KILLINGSWORTH, ENNIS LANKFORD, Taylor, Tex. (Age 41.) City Engr. Refers to E. A. Baugh, M. Hannah, C. H. Harrison, V. G. Koch, D. L. Lewis, H. P. McFarland, Jr., R. J. Potts, W. H. Prentice, Jr., J. H. Strange, S. R. Wright.

KOUSMITCH, NICHOLAS SIMON, New York City. (Age 39.) Gen. Contr., (Kous Constr. Co.). Refers to M. E. Gilmore, S. G. Hess, L. G. Holleran, G. B. F. Lund, G. S. Rinehart.

KOVALEFSKY, ALBERT STEPHEN, Atlanta, Ga. (Age 23.) Camp duties with Officers' Reserve Corps. Refers to R. P. Black, C. D. Gibson, F. C. Snow.

KYSER, JOHN LEWIS, Grenola, Kans. (Age 21.) Refers to L. E. Conrad, F. F. Frazier, M. W. Furr.

LAWRENCE, JOHN HEYER, Baltimore, Md. (Age 31.) Mech. Engr. for Engr. of Plant Div., Western Elec. Co., Inc., Point Breeze Works. Refers to E. C. Lawrence, H. G. Perring, A. M. Quick, J. T. Thompson, F. C. Wachter.

LILLEVANG, OMAR JOHANSEN, South Gate, Calif. (Age 22.) Refers to L. E. Anderson, B. A. Etcheverry, G. A. Gallagher, S. T. Harding, C. T. Wiskocil.

LYONS, DAN JOSEPH, Tucson, Ariz. (Age 40.) Res. Engr., Arizona Highway Dept., Phoenix, Ariz. Refers to J. E. English, G. T. Grove, W. R. Hutchins, W. S. King, J. W. Powers.

MACDONALD RALPH CONNER, Berkeley, Calif. (Age 23.) Refers to C. Derleth, Jr., C. T. Wiskocil.

MCCALL, RICHARD HAWLEY, Waco, Tex. (Age 20.) Refers to L. E. Grinter, J. T. L. McNew, T. A. Munson, J. A. Orr, J. J. Richey, C. E. Sandstedt.

MCGANN, ROBERT JAMES, Berkeley, Calif. (Age 22.) Refers to R. E. Davis, C. Derleth, Jr., B. Jameyson, C. T. Wiskocil.

MCKNIGHT, CLAIR JEFFRIES, Middletown, Ohio. (Age 33.) Engr., Drainage Products Div., The Armco International Corporation. Refers to H. M. Chadwick, J. J. Collins, W. K. Hatt, W. V. McMenimen, M. C. Patton, G. E. Shafer, A. W. Spaulding.

MALVEN, STEPHEN ST. JOHN, College Station, Tex. (Age 22.) Refers to L. E. Grinter, J. T. L. McNew, J. J. Richey.

MARINER, HOBART GRAHAM, Fredonia, Kans. (Age 22.) Refers to L. E. Conrad, F. W. Epps.

MARQUETTE, LOUIS LEDDON, Bryan, Tex. (Age 24.) Refers to L. E. Grinter, J. T. L. McNew, T. A. Munson, J. J. Richey, C. E. Sandstedt.

MARSHALL, ROBERT FREDERICK MERRICK, Montreal, Que., Canada. (Age 36.) Designing Engr., The Foundation Co. of Canada, Ltd. Refers to L. H. Burpee, A. Gordon, P. B. Motley, G. E. Shaw, F. P. Shearwood, D. C. Tennant.

MATTER, KNOX ANDREW, Belle Fourche, S.Dak. (Age 25.) Refers to A. A. Chenoweth, E. D. Dake.

MELLGREN, PALMER MARTIN, Cleburne, Kans. (Age 24.) Refers to L. E. Conrad, M. W. Furr.

METCALFE, JOSEPH DAVIS, College Station, Tex. (Age 20.) Refers to J. T. L. McNew, J. J. Richey.

MILFORD, WILLIAM FREDERICK, JR., Calumet, Mich. (Age 25.) Refers to G. C. Dillman, W. C. Polkinghorne.

MILLER, EDWARD JEREMIAH, JR., Oxford, Miss. (Age 24.) Refers to C. E. Downing, A. B. Hargis, R. B. B. Moorman.

MILLER, JACOB JOHN, Ingram, Pa. (Age 26.) Jun. Engr., U. S. Army Engrs., Pittsburgh, Pa. Refers to W. T. Barnes, K. H. Shriver.

MOHR, CHARLES MILTON, Chicago, Ill. (Age 22.) Refers to D. C. A. du Plantier, J. S. Leister.

MORGAN, JOHN ROLLIN, Modesto, Calif. (Age 21.) Refers to B. A. Etcheverry, C. T. Wiskocil.

MORRIS, GEORGE AUGUSTUS, Vicksburg, Miss. (Age 30.) Engr., U. S. Engr. Office. Refers to O. G. Baxter, W. M. Borgwardt, F. J. Brown, G. R. Clemens, P. E. Cunningham.

MOULTON, JOHN JESSE, Weymouth, Mass. (Age 24.) Refers to F. W. Garran, W. P. Kimball.

NESTO, RAYMOND ROCCO, Newark, N.J. (Age 23.) Refers to F. L. Martin, J. G. Shryock.

NOBLE, JOHN LOCKE, Manhattan, Kans. (Age 23.) Refers to L. E. Conrad, F. F. Frazier, M. W. Furr, C. H. Scholer, L. V. White.

NORMAN, CLYDE THOMAS, Dallas, Tex. (Age 27.) Refers to L. E. Grinter, K. F. Hoefle, J. T. L. McNew, J. A. Orr, J. J. Richey.

NUSSBAUMER, FRED WILLIAM, Lebanon, Kans. (Age 28.) Refers to L. E. Conrad, M. W. Furr.

ORMSBY, ORVILLE HENRY, Laurium, Mich. (Age 23.) Refers to G. C. Dillman, W. C. Polkinghorne.

PADDOCK, LEON ALFRED, Pittsburgh, Pa. (Age 58.) Pres., Virginia Bridge Co. Refers to C. G. Conley, A. J. Dyer, C. F. Goodrich, J. D. K. Lyman, E. H. Heald, R. Khuen, Jr., A. F. Reichmann.

PRICE, ROBERT CARMEL, Adjuntas, Puerto Rico. (Age 35.) Senior Constr. Engr., Puerto Rico Reconstruction Administration. Refers to R. J. Bassett, C. E. Blee, C. A. Bock, J. S. Bowman, F. A. Dale, R. M. Riegel, W. W. Schlecht, H. H. Steinhauser, F. Towle.

PRICE, WRIGHT MOORE, Chattanooga, Tenn. (Age 33.) Asst. Cost Engr., Chickamauga Dam, TVA. Refers to F. T. Crowe, A. Donaldson, F. T. Hickerson, J. S. Lewis, R. H. Taylor.

PRICHARD, GEORGE WILLIAM, Kansas City, Mo. (Age 29.) Instrumentman and Asst. Project Engr., Missouri State Highway Dept. Refers to E. B. Black, W. H. Bosier, J. H. Brooking, J. F. Brown, H. M. Brush, W. M. Spann, E. M. Stayton.

PRINCE, ELMER WOODWARD, Morgantown, W.Va. (Age 40.) City Mgr., City Engr., Supt. of Streets and Sewers, Supt. of Sanitation and Bldg. Inspector. Refers to G. H. Bayles, T. F. Boltz, H. O. Cole, R. P. Davis, W. S. Downs, N. Schein, G. W. Schusler.

RACKI, Matt MICHAEL, Beaumont, Tex. (Age 22.) Refers to J. T. L. McNew, J. J. Richey.

RALPH, ORVILLE MARSHALL, Brownsville, Tex. (Age 24.) Refers to L. E. Grinter, J. T. L. McNew, T. A. Munson, J. A. Orr, J. J. Richey C. E. Sandstedt.

RANDOLPH, GAYLE BOWDEN, JR., Madisonville, Tex. (Age 22.) Refers to L. E. Grinter, J. T. L. McNew, T. A. Munson, J. A. Orr, J. J. Richey, C. E. Sandstedt.

REARDON, LESLIE JOSEPH, Cleveland, Ohio. (Age 41.) Res. Engr. Inspector, PWA, Middletown, Ohio, also Chf. of Govt. Staff. Refers to A. Miller, F. L. Plummer, H. C. Plummer, W. E. Rice, E. L. Winslow, Jr.

REEVES, HARRY MILTON, Norris, Tenn. (Age 38.) Area Engr., Clinch-Holston Area, TVA, Knoxville, Tenn. Refers to J. S. Bowman, F. M. Dawson, A. S. Fry, G. H. Hickox, R. E. Hutchins, B. E. Morriss, J. Smallshaw.

RICHARDS, GORDON VAUGHN, Placerville, Calif. (Age 21.) Refers to C. Derleth, Jr., C. T. Wiskocil.

RICHMAN, WALLACE RIDGWAY, College Station, Tex. (Age 25.) Refers to L. E. Grinter, J. T. L. McNew, T. A. Munson, J. J. Richey, C. E. Sandstedt.

RICHMOND, WALLACE PARRISH, Kyle, Tex. (Age 21.) Refers to L. E. Grinter, J. T. L. McNew, T. A. Munson, J. A. Orr, J. J. Richey, C. E. Sandstedt.

ROYCE, THOMAS COCHRAN, Long Beach, Calif. (Age 28.) Refers to C. Derleth, Jr., C. T. Wiskocil.

SALSER, SILTON SEAWRIGHT, Temple, Tex. (Age 36.) Asst. Cadastral Engr., Area Engr., Brazos River Conservation and Reclamation Dist. Refers to J. R. Coltharp, E. Haquinius, G. C. Morriss, J. A. Norris, N. C. Woody.

SCHLICK, JULIUS REID, Tuscaloosa, Ala. (Age 25.) Refers to D. C. A. du Plantier, J. S. Leister.

SCHOLES, THOMAS FRANCIS, Paoli, Pa. (Age 23.) Asst., Eng. Corps, Pennsylvania R.R., Philadelphia, Pa. Refers to M. B. Case, J. S. Crandell, J. J. Doland, O. E. R. McMullin, F. T. Sheets.

SCOTT, VERON EUGENE, Little Rock, Arkansas. (Age 45.) Asst. to State Director, State Office, PWA. Refers to A. Allaire, W. D. Dickinson, N. B. Garver, L. L. Hidinger, D. A. MacCrea, J. M. Page, W. W. Zass.

SELLNER, EDWARD, Gatesville, Tex. (Age 24.) Asst. Office Engr., Texas State Highway Dept. Refers to G. E. Barnes, L. E. Grinter, J. T. L. McNew, F. L. Plummer, J. J. Richey, C. E. Sandstedt.

SHOEMAKER, WILLIAM HERBERT, Woodstock, Va. (Age 21.) Refers to R. B. H. Begg, F. J. Sette.

SLOAN, WILLIAM HENDERSON, San Benito, Tex. (Age 22.) Refers to L. E. Grinter, J. T. L. McNew, J. A. Orr, J. J. Richey, C. E. Sandstedt.

SMITH, FREDERICK CHARNLEY, Seattle, Wash. (Age 53.) Asst. Prof. of Civ. Eng., Univ. of Washington. Refers to F. C. Dunham, R. M. Harris, T. D. Hunt, L. V. Murrow, R. G. Tyler.

SMITH, ROGER WHALEN, Independence, Kansas. (Age 35.) Senior Designer with State Highway Comm. of Kansas. Refers to H. D. Barnes, O. J. Eidmann, G. H. Hackmaster, G. W. Lamb, R. M. Willis.

SMITH, WALTER PRESTON, San Francisco, Calif. (Age 24.) Refers to C. Derleth, Jr., C. T. Wiskocil.

SMITH, WILBUR STEVENSON, Columbia, S.C. (Age 25.) With South Carolina State Highway Dept. Refers to W. E. Rowe, R. L. Sumwalt.

SPEARS, SHOLTO MARION, Chicago, Ill. (Age 36.) Associate Prof. of Civ. Eng., Armour Inst. of Technology. Refers to J. G. Bennett, J. F. Mangold, H. Penn, J. C. Penn, R. L. Stevens, H. A. Vagtborg.

STAPLES, ERCELLE HORACE, Ennis, Tex. (Age 21.) Refers to L. E. Grinter, J. T. L. McNew, J. A. Orr, J. J. Richey, C. E. Sandstedt.

STEEL, ERNEST WILLIAM, College Station, Tex. (Age 43.) Prof., and Head of Dept., of Mun. and San. Eng., Agricultural and Mechanical Coll. of Texas. Refers to E. P. Arneson, S. W. Freese, J. B. Hawley, D. L. Lewis, J. T. L. McNew, M. C. Nichols, S. R. Wright.

TAGGART, DANIEL BROWN, Williamsport, Pa. (Age 27.) Refers to F. W. Garran, W. P. Kimball.

TEILMAN, INGVART HOLM, Selma, Calif. (Age 48.) Chf. Engr. and Mgr., Consolidated Irrigation Dist. Refers to J. B. Brown, J. B. Christiansen, B. A. Etcheverry, A. J. Gerner, H. L. Haehl, S. T. Harding, H. H. Holley.

TERHUNE, VICTOR WILLETT, Richmond, Ind. (Age 28.) Project Engr., Constr. Dept., Indiana State Highway Comm. Refers to W. J. Henderson, G. E. Lommel, J. S. Neibert, B. E. Phelps, R. B. Wiley, J. H. Wilson.

THOMPSON, SAMUEL HYDE, Washington, D.C. (Age 38.) Engr., Federal Power Comm. Refers to P. A. Franklin, N. C. Grover, R. F. Hoffmark, C. S. Jarvis, T. R. Lawson, R. B. McWhorter, G. S. Thompson, F. S. Warner, A. Wolman.

THOMSON, CARL WHEATLEY, Sacramento, Calif. (Age 21.) Refers to C. Derleth, Jr., C. T. Wiskocil.

THREADGILL, WALTON ORVILLE, Bellevue, Tex. (Age 21.) Refers to L. E. Grinter, J. T. L. McNew, J. A. Orr, J. J. Richey, G. E. Sandstedt.

TRAVIS, JAMES EDWARD, Hales Corners, Wis. (Age 37.) Associate Civ. Engr., Suburban Div. Resettlement Administration, U. S. Dept. of Agriculture. Refers to J. L. Crane, Jr., W. E. Kroening, G. L. Opper, C. D. Putnam, E. D. Roberts.

TUHUS, KENNETH, Mitchell, S.Dak. (Age 29.) State Hydr. Engr., WPA. Refers to F. M. Dawson, H. F. Janda, W. J. Landwehr, D. W. Mead, H. W. Mead, R. E. Toole, L. P. Van Hagan.

WEATHERLY, EVERETT PINE, JR., Kansas City, Mo. (Age 29.) Secy.-Treas., List & Weatherly Constr. Co. Refers to J. H. Brooking, C. E. Brown, W. F. Kuehne, A. B. Taylor, E. P. Weatherly.

WETZEL, JOHN HENRY, Williamsport, Pa. (Age 27.) Asst. Regional Engr., Soil Conservation Service, U. S. Dept. of Agriculture. Refers to E. R. Cary, H. W. Hobbs, C. S. Jarvis, E. R. Kinnear, H. O. Sharp.

WHITE, ROBERT EMELIN, St. Louis, Mo. (Age 24.) Engr. with Eng. Constr. Corporation. Refers to G. Paaswell, E. A. Prentis, R. Ridgway, F. B. Spencer.

WILLIAMS, ELIAS JONCE, JR., Vicksburg, Miss. (Age 33.) Asst. Engr., Mississippi River Comm. Refers to J. B. Alexander, S. J. Buchanan, T. S. Burns, G. R. Clemens, H. Kramer, C. P. Lindner, G. H. Matthes, H. Rubey, G. M. Tapley.

WILLIAMS, WALTER BELFORD, Paris, Tex. (Age 27.) Asst. Res. Engr. with Texas State Highway Department. Refers to L. D. Cabaniss, C. C. Cagle, F. M. Davis, H. H. Peel, J. E. Pirie.

WISE, JOSEPH ALEXANDER, Minneapolis, Minn. (Age 40.) Jun. Bridge Designer, Minnesota State Highway Dept. Refers to F. S. Altman, F. Bass, A. S. Cutler, H. G. Overholt, L. G. Straub.

WOOLVERTON, MARGARET GENEVIEVE, Stanford University, Calif. (Age 23.) Refers to E. L. Grant, S. B. Morris, L. B. Reynolds.

WRIGHT, JOHN SUAREZ, New York City (Age 23.) Refers to T. F. Comber, Jr., J. T. Thompson.

YODER, HAROLD BLOSSER, Santa Fe, N.Mex. (Age 33.) Asst. Maintenance Engr., New Mexico State Highway Dept. Refers to H. A. Bestor, J. H. Bliss, G. F. Conroy, J. H. Dorroh, B. G. Dwyre, P. S. Fox, J. C. Harvey, B. Johnson, A. R. Losh, T. M. McClure, G. D. Macy, G. M. Neel, L. C. Rockett, W. E. Strohm.

ZIEGLER, AMOS ADDIS, JR., Drexel Hill, Pa. (Age 22.) Refers to F. W. Garran, W. P. Kimball.

FOR TRANSFER

FROM THE GRADE OF ASSOCIATE MEMBER

ALDEN, LANGFORD TAYLOR, Assoc. M., Riverhead, N.Y. (Elected Sept. 2, 1914.) (Age 50.) Res. Engr. Inspector, PWA, Inspection Div. Refers to C. E. Blee, W. Charnley, M. F. Gilmore, S. R. Jones, W. F. Way, F. G. White, A. D. Wilder.

CANFIELD, GEORGE HOWARD, Assoc. M., Portland, Ore. (Elected June 3, 1915.) (Age 51.) Dist. Engr., Portland Dist., Water Resources Branch, Surface Water Div., U. S. Geological Survey. Refers to J. W. Cunningham, L. Griswold, N. C. Grover, G. L. Parker, C. G. Paulsen, H. A. Rands, H. Stabler, J. C. Stevens.

HOMEYER, MAX PAUL VON, Assoc. M., Austin, Tex. (Elected Oct. 14, 1929.) (Age 41.) Res. Engr., Road Design Div., Texas State Highway Dept. Refers to J. A. Focht, T. E. Huffman, E. E. Pittman, O. A. Seward, Jr., W. M. Wilson.

HUBER, EARL RAYMOND, Assoc. M., San Francisco, Calif. (Elected Junior Oct. 21, 1924; Assoc. M. May 13, 1929.) (Age 35.) Bridge Engr., Region 5, U. S. Forest Service. Refers to J. I. Ballard, J. C. Beebe, H. D. Dewell, J. D. Galloway, W. L. Huber, E. M. Knapik, J. H. Lawrence.

LITEHISER, ROBERT REID, Assoc. M., Columbus, Ohio. (Elected Dec. 16, 1929.) (Age 44.) Chf. Engr., State Highway Testing Laboratory. Refers to L. M. Arms, E. C. Bloser, O. Bonney, W. V. Buck, R. W. Crum, W. E. Hart, J. W. Kelly, C. T. Morris, C. H. Sutherland, R. N. Waid, S. Walker, G. E. Warren.

POLKINGHORNE, WILFRID CARLOS, Assoc. M., Houghton, Mich. (Elected June 9, 1930.) (Age 45.) Associate Prof. of Civ. Eng., Michigan Coll. of Mining and Technology. Refers to C. T. Bishop, T. Crane, G. C. Dillman, C. S. Farnham, P. G. Laurson, R. C. Young.

SHANE, HENRY KAMSLER, Assoc. M., Kansas City, Mo. (Elected May 23, 1932.) (Age 35.) Asst. Hydr. Eng. Sec. Head, War Dept., U. S. Army (Capt., Engr. Reserve Corps). Refers to E. B. Black, J. F. Brown, G. A. Hathaway, J. O'C. Hunt, E. F. Petersen.

VAN ECNAM, NEIL, Assoc. M., Washington, D.C. (Elected Junior March 11, 1919; Assoc. M. Oct. 2, 1922.) (Age 44.) Associate Highway Bridge Engr., U. S. Bureau of Public Roads. Refers to G. C. Dillman, O. L. Grover, C. A. Melick, N. W. Morgan, J. L. Parker, J. I. Quinn, A. Streiff.

FROM THE GRADE OF JUNIOR

BAILEY, WILLIAM ATTERBURY, Jun., Berkeley, Calif. (Elected May 28, 1933.) (Age 31.) Jun. Bridge Constr. Engr., San Francisco–Oakland Bay Bridge. Refers to C. E. Andrew, C. R. Harding, A. D. Hunting, F. R. Muhs, D. R. Warren, H. Whipple.

BIRDSALL, BLAIR, Jun., Trenton, N.J. (Elected Jan. 26, 1931.) (Age 30.) Engr., Bridge Dept., John A. Roebling's Sons Co. Refers to G. E. Beggs, J. R. Blondin, R. G. Cone, F. H. Constant, R. W. Downs, W. E. Joyce, A. F. Samuel, Jr.

CONTRERAS, MARIANO JESUS, Jun., Caracas, Venezuela. (Elected Nov. 12, 1928.) (Age 33.) With Ministry of Public Works on development of La Guaira Harbor. Refers to E. Aguerrevere, J. M. Bayot, V. De Chelminski J. M. Ibarra Cereso, J. R. Stubbins.

COOK, ROBERT ELTON, Jun., Santa Fe, N.Mex. (Elected Oct. 14, 1930.) (Age 33.) Asst. Engr. with U. S. Geological Survey, Tucson, Ariz. Refers to E. L. Barrows, J. A. Baumgartner, W. E. Dickinson, J. S. Gatewood, B. Johnson, C. A. McClelland.

CORNELL, GEORGE MILTON, Jun., Huntington, W.Va. (Elected March 14, 1927.) (Age 32.)